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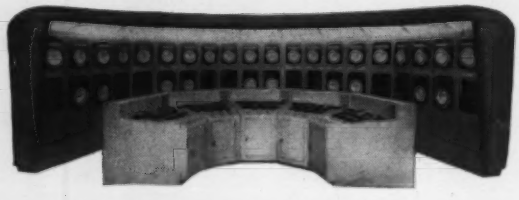

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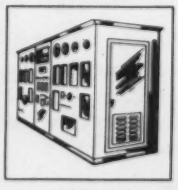

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Instruments

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EDITORIAL

Instrumentation Conquers the Sonic Barrier

By M. F. BEHAR

MOST *Instruments* readers know that there isn't any sonic barrier as dramatized in hair-raising fiction with gruesome details of, say, a JATO-equipped passenger plane suddenly shattered as if crashing into a cliff when the pilot turns on the assist-jets in full flight in a daredevil attempt to "take her from Mach 0.85 to Mach 1.15."

Readers who smile at such stories and at the "explanations" of the sonic barrier in Sunday supplements and in newsstand pseudo-science magazines* are the very ones who have the greatest respect and admiration for the tiny handful of designers of supersonic airplanes and missiles. They appreciate a situation which may be stated as follows:

THE REAL SONIC BARRIER CONSISTS IN THE MATHEMATICAL COMPLICATIONS OF INTERFERENCE EFFECTS. One smooth solid projectile with circular cross-sections from pointed tip to boat-tail does not present a difficult problem; neither does one airfoil of uniform section. But even the simplest-looking combination of a body and two wings (no control-surface tail assembly) sets up interference patterns for which mathematicians could not derive the formulas without benefit of test results. And if vertical and horizontal control surfaces were to be added at the tail, not even a genius could, without test results, design these surfaces and predict their hinge moments for flight conditions. (without measurements of hinge moments, specifying a servomechanism for autopiloting amounts to writing: "Build us a one-horsepower servo occupying one cubic inch, weighing one ounce, and capable of reversing from full-speed clockwise to full-speed counterclockwise under full load in one-tenth of a second.")

So formidable is the sonic barrier, IN THIS SENSE, that even with computing machines that reduce months of human computations to minutes or seconds, it still takes years to solve certain major problems.

Fortunately, satisfactory answers to specific questions come up with gratifying ease through testing models and prototypes with properly selected instruments correctly installed to measure the numerous parameters: thus can theory and experiment aid each other and together march forward by giant steps, whereas each alone could only creep in zig-zag paths and all too many blind alleys. Compare the many years it took to achieve the design of standard airfoils (now called subsonic), with the relatively rapid wartime evolution of the transonic and supersonic airfoils.

But testing models at supersonic speeds is a tremendously difficult job. Until a few weeks ago it could not be done the right way, which is CONTINUOUSLY and with provisions for exquisitely close readjustments of speed, density and other conditions IN THE COURSE OF ONE TEST. Until about three years ago, a "test" lasted from an instant (one good set of photographs) to a few seconds (free-flight observations); such a test yielded elementary stability measurements but did not yield the measurements required for designing control surfaces and their servos. The job is made tremendously difficult by three sets of problems:

(1) Full-scale free-flight observations are costly because each aircraft model is destroyed wholly or in large part at the end of its flight.

(2) The construction of even a "small" continuous-operation supersonic-speed wind tunnel is a great and complicated engineering problem.

(3) The whole purpose of a wind tunnel is to yield accurate measurements. To measure all the forces and other pertinent variables, without seriously altering them by the mere presence of measuring elements, wires, rods, etc., in the stream or on the model, is a thousand-sided problem that taxes the ingenuity of the best designers in instrument companies, in Armed Forces and company laboratories, in the National Bureau of Standards, in universities, etc.

These three sets of problems will be taken up in detail later. At this point it is proper to mention that Armed Forces scientists for many years have made supersonic speeds in the atmosphere a subject of study, for the obvious reason that most projectiles are fired with a muzzle velocity higher than the speed of sound, and for the life-and-death reason that the trajectory depends on the shape, weight distribution, etc., of the bullet or shell and on the atmospheric conditions between the firing point and the target. Some men who went to officers' schools before World War I can dig out, from the mementos in battered old trunks, notebooks and exam papers on Exterior Ballistics that might astonish the bright youngsters who study or practice aero-

THE EVENT

From all parts of the country, reporters and editors came to Aberdeen, Maryland, on Monday, May 17th. They represented all levels of the printed word—from scientific journals to newspapers—at the dedication of the Army's Flexible-throat Supersonic-speed Wind Tunnel. They gathered in a meeting room half-a-mile from the Wind-tunnels Laboratory. After speeches by dignitaries, Colonel L. E. Simon, Director of the Ballistic Research Laboratories, spoke briefly on the installation; Colonel H. H. Zornig, his predecessor from 1936 to 1941, formally dedicated it; Robert H. Kent, who heads the civilian scientists, formally accepted it and then pressed a push-button. Three things happened at once:

The lights went out.

A 75-decibel roar, as of jet planes close overhead, filled the hall.

Two illuminated screens, each about 15" × 18", so placed that everybody could plainly see at least one, flashed into view. Both showed the same simple picture: on a bright pale-green background a black cigar-like object, its point in the center and its rear end hidden by the right edge of the screen; from the point to the top and bottom edges, two thin dark lines, each at an angle slightly less than 45 degrees to the object, thus forming less than a right angle.

How much less? *So little* that some spectators did not see anything to marvel at; *so much* (46°) that many of the privileged spectators had believed, a few short years ago, that they would not live to see it.

It was a thrilling moment. Those in charge wisely prolonged it. Spectators began to exchange comments, speaking loudly like passengers in a non-soundproofed airplane. Two of them—evidently non-technical newsmen—were overheard by a third: they were commenting sarcastically that the picture was not a movie but only a still and that they had not been told what it showed; they wise-cracked on the prolongation of its showing and of the noise. For the third spectator these remarks broke the spell as rudely as would the braying of an ass during a Handel oratorio. Nevertheless, for the sake of the readers of the next day's newspapers, he explained:

"These are two television screens. The pick-up is in front of the test section of the tunnel half-a-mile away. We are seeing air rushing past the model of a guided or homing missile. We can't see undisturbed air but we see the compression waves. They are made visible by the Schlieren method—like you've seen 'invisible' effects by using polaroids. The noise is that of the tunnel: just what we would hear if we stood near it. It's a loud noise because when ten thousand horsepower is used to move air, the least roughness or bend in the duct walls acts like a whistle or like an organ pipe. The tunnel itself is one huge wind instrument. The speed of the air in this televised section is three thousand miles per hour."

After the ceremonies, this third spectator was pleased to see newsmen taken in hand by courteous officers. But the newspapers of Tuesday, May 18th buried the story or killed it.

Busy newspaper editors could be excused for not knowing that this "non-atomic" unspectacular event rated half a column and an interpretive editorial. We believe that in *Instruments* it rates even more than the five pages we give it.

*Perhaps one should not be too hard on popular writers and radio commentators, because the expression "the sonic barrier" had appeared and still appears in serious technical books and journals. Here are pertinent facts:

(1) About two decades ago it began to be used in texts on aerodynamics in connection with drag formulas with inverse square of Mach number difference as a compressibility factor. Some formulas, in abridged from, held true for low speeds only (and could be used in these days of low speeds) but they implied that the drag became infinite at sonic speed. Their use led a few workers to believe that the transonic zone was **impenetrable** by self-propelled aircraft accelerating from low speeds. To them, the "barrier" meant that no engine could make an airplane attain a speed of over 650 or 700 mph.

(2) More recently, the expression "sonic barrier" began to be used by professors of aerodynamics in a purely figurative sense to denote a sharp boundary between two of the **subjects** they taught. They used it to explain that the basic principles of supersonic aerodynamics (zone of silence, cone of action, forbidden signals, concentrated action, wave-drag and sweep-back, etc.) resembled the basic principles of acoustics, whereas the basic principles of subsonic aerodynamics resembled those of fluid flow.

(3) About four years ago, in the midst of war news, when the public eagerly read items on aviation advances (and when censorship precluded disclosing **specific** advances) there appeared the first accounts of the "sudden discovery" of the "knife-edge" principle—popularizations of technical articles describing without fanfare the progress in three distinct airfoil designs: the subsonic airfoil, the supersonic airfoil and the transonic airfoil. The popular writers pounced on the word "transonic" and some of them began to emphasize the "sonic barrier" in various imaginative ways.

(4) About two years ago, the NACA unveiled the Bell XS-1 designed specifically for studying high-speed flight problems; announced that it would be used for flight research up to M 1.2 "if possible"; and stated that the XS-1 would probably encounter severe changes in control characteristics in the transonic region from about M 0.8 to M 1.2. Newspapers and radio commentators immediately jumped in with great gusto, some saying that flying the XS-1 would be suicide; other popular writers climbed on the bandwagon; and all of them had a field day ever since. Why not? The public loves it!

It can safely be predicted that it will **soon** be revealed that XS-1 (**and other**) pilots have flown at more than sonic speed **many times.**

dynamics today and who think that nobody knew anything about supersonics before World War II.*

Ballisticians began to develop instrumentation for supersonic-speed testing before the birth of commercial aviation. When commercial aviation was in its infancy, when aerodynamic research was struggling for endowments, and when both regarded supersonic speed as a dream, research projects involving tens of thousands of supersonic measurements were well under way at the BRL—the Ballistic Research Laboratories of the Army's Ordnance Department.

Likewise worth noting here is another near-coincidence: It was just about ten years ago that, on the one hand, aeronautical institutions began to consider supersonic phenomena a major subject; and that, on the other hand, ballisticians began to consider subsonics a major subject!

In this connection it is fitting to note here, also, that ballisticians found most of the "new" instruments they needed (for subsonic-speed studies) to have been developed previously in the various fields of aviation. Many types of airborne and ground instruments could be used unmodified for research on the new fin-stabilized bombs, gently-accelerated missiles and—of course—controlled-flight missiles resembling airplanes, all traveling at subsonic speeds initially or throughout their flights.

A few weeks ago Colonel Leslie E. Simon, Director of the BRL, told the Philadelphia Section of the Institute of Aeronautical Sciences that in recent years the advent of relatively slow missiles "not only gave ballisticians an interest in subsonic phenomena but also stimulated the search for a thorough knowledge of aerodynamic phenomena." He emphasized instrumentation so much that we think his IAS talk could have been entitled: "Instrumentation Brings Together Aerodynamics and Ballistics by Enabling Each to Explore the Other Side of the Sonic-speed Fence Previously Separating Them." He emphasized also the relative slowness of advances in the sciences common to both fields and denied that there had been a sudden dramatic conquering of a so-called sonic barrier. Said he: "There has been merely a gradual increase in knowledge, a period of identifying phenomena and devising instruments to measure them."

It is almost an interfusion of aerodynamics and ballistics —certainly a rich cross-fertilization—that is being ushered in by the research and development programs now beginning to take advantage of the BRL's facilities. By the way, Congress did not pinch pennies: it appropriated enough money, so that many new jobs of interest to our readers are open at the BRL. Instrument specialists are urgently needed, we learn, though official Government job classifications use such titles as "mechanical engineers" (up to $4902 a year), "electrical engineers" (to $7102), "ordnance engineers" (to $8179), "physicists" (to $9975), etc. Some accepted applicants might not be stationed at Aberdeen but in the Southwest and elsewhere.

We mention the Southwest in particular because "nobody knows" that ALL the ballistic measurements made at the White Sands Proving Ground (New Mexico) are delegated to the BRL at Aberdeen. Those various "measurements by radio"—which radio commentators mention whenever a V-2 or other sensational missile is launched—are made with instruments most of which have been developed by the BRL in Maryland. Groups of men who ceaselessly shuttle between the BRL and White Sands develop and test new instruments and new techniques, making use of all applicable older elements as well as devising new ones representing truly new methods. But they are not the only ones who do so for the BRL itself, or at the BRL for the institutions served by the BRL. Moreover, the expansion of the waiting-list of the BRL's "customers" foretokens further expansion of work, of facilities and of instrument personnel. The BRL's Supersonic-speed Tunnels Laboratory has so many development "rush orders" from its "customers" that two-thirds of available wind tunnel time is allotted to testing and one-third to research. "This policy," declares Colonel Simon, "has affected the viewpoint of our whole work, and perhaps not unfavorably."

It must be borne in mind that most of the BRL's current work has to do with free-flight studies, as in the past. Moreover, we believe that the event *Instruments* is celebrating—the completion of the flexible-throat supersonic-speed tunnel, cutting down development times from decades to months in some cases—will lead to greater demands for use of the BRL's elaborate free-flight testing instrumentation. A brief outline of free-flight testing is in order at this point. The BRL's testing equipment comprises aerodynamic ranges, the Missile Ballistic Range, and the equipment at White Sands.

The principal Aerodynamic Range is an indoor range 300 feet long, with 25 spark-photography stations. In total darkness no cameras are needed: shadowgraphs are taken by automatic timing of the 2-microsecond-duration flashes. By means of mirrors a second photograph is taken at right angles to each directly-exposed plate. Thus fifty pictures are taken as the model travels to the backstop, each picture showing, thanks to high-precision chronoscopic and cathode-ray oscillographic instrumentation, the model's exact position and exact orientation. For small models, these exact measurements over the 300-foot distance permit determining dynamic characteristics which cannot be determined in wind-tunnel tests where models are mounted or suspended. But model-making is far more expensive and difficult than for wind tunnels. Not only must integrity of shape be preserved; not only must center of gravity, moments and other physical constants be held; but the model must be strong enough to stand gun-tube accelerations of 100,000*G*. Colonel Simon said that "some models have fins of high-tensile steel, part of the body of gold-platinum alloy for density and other parts of aluminum alloy for lightness." There being no opportunity for repeated measurements on a single model, results must be obtained statistically by firing a number of models, all made nearly "identical" at great expense.

(The X-bore gun for firing complicated missiles with fins and wings, and other details, are marvels of ingenuity but are not instruments—though they are components of the testing instrument known as the Aerodynamic Range—so that this mention must suffice.)

The BRL's Missile Ballistics Range serves a similar purpose but is 2¼ miles long and, of course, an outdoors range with numerous camera stations. A flight-line guides the pilot of a rocket-firing jet plane past carefully-surveyed positions, each equipped with a pair of high-speed motion-picture cameras which record position and orientation of the airplane and the missile which it launches. Each motion-picture frame registers time, from one central instrument, to ten microseconds. Full-scale pilotless aircraft are tested on this range and the obtainable measurements of automatic-control responses furnish adequate answers to many theoretical and practical questions. This range at Aberdeen is probably the world's only facility for this sort of work.

The Full-scale Free-flight Ranges, at White Sands, operate under the Commanding General of that Army Post, but the instrumentation facilities may be said to be a "colony" of the BRL. Most spectacular is the DOVAP (Doppler Velocity and Position) system whereby the distance of a missile is recorded at every instant of its flight with a maximum error of about 66 inches, even at its highest altitude of 100 miles or more, by means of a combination of radar and beat-frequency instruments, supplemented by the electronic and electromechanical computing instruments at Aberdeen. These are necessary because the straight-line distances to seven ground stations obtained by DOVAP are only the raw data for computing the trajectories and because the solution of a set of equations in twenty-eight parameters is too long a task for human mathematicians.

Free-flight observations have been, for decades, proving their value in improving the designs of supersonic-speed bullets, shells and other relatively simple shapes; but, with regard to supersonic-speed airplanes and guided missiles, they have serious limitations: (a) they preclude the use of

*It is perfectly true, however, that the total knowledge of supersonics possessed by all the world's military and civilian scientists before World War II included few, if any, practical data on CONTROLLED flight at supersonic speeds. But nobody felt the need of greater knowledge of supersonics more keenly than did the ballisticians themselves. It was they who, in the expression for the ballistic coefficient, $C=m/id^2$—familiar to artillerymen and to many other servicemen—called i the "COEFFICIENT OF IGNORANCE." (Of course, in their printed texts and mimeographed lessons, i was precisely called the experimental-determined form factor.)

external instruments connected to the supersonic plane or missile by pressure tubes, electric wires, etc.; (b) schlieren photographs can only be taken over small portions of the flight; (c) ordinary photography yields too few data, especially when taken from miles away; (d) internal flight-test instrumentation with autographic and photographic recording and with radio telemetering, as successfully installed on already-built full-size subsonic-speed airplanes, must await the complete building of a full-scale prototype supersonic-speed aircraft, which in turn must await the completion of a costly design project; (e) each model or full-scale prototype, costing up to $1,000,000, is used only once; (f) the occupational hazards are by no means negligible.

Hence the imperative necessity of an instrument for thoroughly testing models at supersonic speeds continuously and with smoothly-variable conditions—like those now-familiar huge testing instruments known as wind-tunnels (soon to be called subsonic-speed wind tunnels).

The second set of difficulties spring up in the design and construction of this new type of testing instrument, the supersonic-speed wind tunnel. The basic problem arises from the nature of a gas mixture such as air—from the speeds of its molecules at various temperatures, from the relations of temperature, pressure and density, from the equally well-known and equally inconvenient fact that water vapor turns to rain and to snow as temperature falls when volume expands downstream of the throat.

These implacable laws of Mother Nature render impracticable a "test section" in the open air at the muzzle of a device such as a gun which creates a supersonic-speed stream of powder gases for a moment—or at the muzzle of a "continuous gun" discharging into the atmosphere, even if the blast were to be pure air issuing at constant velocity. (Reasons: extreme difficulty of obtaining homogeneous flow; and tremendous power requirements.)

So the earliest supersonic-speed wind tunnels consisted of room-size vacuum chambers into which air would naturally rush from the atmosphere at the natural speed of its molecules (sonic speed or Mach Number 1) and into which compressed air would rush at a supersonic speed depending on its pre-pressure. This idea resulted in small but useful test sections in which models of the exact shapes under study could be installed, where some forces could be measured and where schlierens could be taken; but the tests lasted less than 15 seconds for M 1.5 and about 18 seconds for M 3.0—long enough for some static stability measurements but too brief for control data. Tests with these intermittent type tunnels are better than nothing, but of little value compared to the wealth of measurements obtained from the continuously-operating subsonic-speed wind tunnels, more than 100 of which are in use in the U.S.

The next development was the continuous-operation supersonic-speed wind tunnel comprising means for continuously exhausting a chamber and means for continuously forcing a stream of air into this partial vacuum. This sounds simple. It is simple in theory. In practice, the difficulties of the engineering problem increase as the cube or as the fourth power of the size. To bring out this point, let us consider one of the two extremes, the extreme of minuteness.

On a miniature scale, the difficulties of practical engineering vanish and most of our readers could build a continuously-operating supersonic-speed apparatus in one afternoon: take a medium-size vacuum pump, a small air compressor, silica gel or other dehydrating means to prevent icing, and pieces of glass tubing and a Bunsen burner for shaping the miniature "nozzle" and "test section." The "throat" would be nail-hole size and the "test section" would be rivet-hole size. The apparatus could only be used for demonstration and only to a disappointingly small extent; it would not be a true wind-tunnel, suitable for testing, because it would not be instrumented. (Incidentally, about the only way to make use of the "test section" would be by photography, and for this purpose one would have to have airplane models the size of a grain of rice. Reason: ratio of test-section diameter to model length must be such as to avoid shock-wave reflections from walls to model.)

The foregoing example was the hypothetical extreme of minuteness and simplicity. Of the actual and useful examples, the smallest probably is the one at the California Institute of Technology. Its test section is only 2.5 inches square (only 6.25 square inches). It began with an Army Ordnance request in May 1939 and an NRC report in July 1940; the contract was awarded in November 1940; it was first operated at supersonic speed in December 1941—these dates giving a good idea of the practical engineering difficulties.

The usefulness of this "working model" at Caltech consisted mostly in showing that a larger one was practicable. Its operation, coinciding with Pearl Harbor, led to the construction of the Supersonic-speed Wind-tunnels Laboratory at Aberdeen—a two-part job or, in reality, a pair of jobs, which in peacetime might have taken ten years. Instead of a dry technical discussion of the greatness of the engineering difficulties, a pictorial editorial on the next two pages will serve the same purpose.

Seldom have taxpayers' millions been spent more fruitfully than on this huge testing instrument. It was planned from the start as a two-tunnel facility. We were at war; "speed and more speed" governed all efforts; there was no time to design and build the "ideal" SSWT; therefore America's first adequate-size SSWT, built in only twenty-two months, was the Fixed-throat Tunnel. Its test section is 15″ wide by 20″ high. It is equipped with interchangeable nozzles: convergent for subsonic speeds, as well as supersonic nozzles for speeds up to M 1.72.

Even before the design of this fixed-throat tunnel was started, the design of the Flexible-throat Tunnel had been initiated. Its installation started in January 1947. A few weeks ago (April 9), M 4 was obtained for the first time.

Important for aircraft and missile development is the size of its test section (15″ wide, height variable from 12″ to 23″) and the ease with which conditions may be changed during a test. Not only is speed continuously variable from below sonic to M 4, but, for almost this entire speed range, a range of about 10 to 1 in Reynolds numbers is obtainable. (Upper limit of density set by overload on compressors; lower limit by the evacuating pumps.) This flexibility makes possible the limitless wealth of measurements which is the dream of aircraft designers.

Measurements, to be useful, must be accurate; hence the third of the three sets of problems mentioned on page 505. Instrumentation problems are complex enough in ordinary wind tunnels (see the new book "Wind Tunnel Testing" by Allen Pope). At Aberdeen they are—to use the BRL's own adjective—"formidable." Examples:

1. Strain-gage-type balances: The greater the weight of an aircraft's servomechanisms and power supplies, the smaller its payload and the shorter its range. Servo power ratings are dictated by control-surface hinge moments. These, therefore, must be measured accurately, with primary elements of balance systems built INTO all models (external rods and wires cannot be used in the supersonic régime).

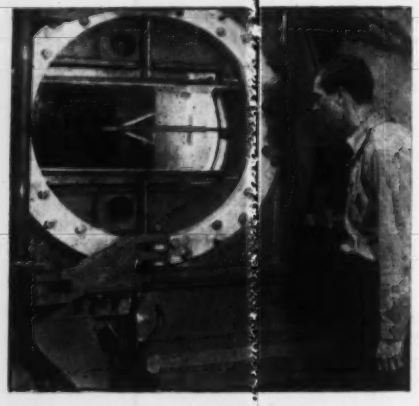
Balances used at the BRL measure the hinge moment due to a half-degree deflection of a control surface with a ¼″ chord and 1″ span; permit accuracy of 0.2° in control-surface incidence setting without affecting any measuring elements; *and fit into a ¾″ o.d. model body!*

2. Pressure equalization: For the all-important three-component force test (lift, drag and pitching moment as functions of angle of attack with various shapes of wings, control surfaces, etc.) the model is supported from the rear by a strut enclosed in a windshield. To avoid errors in force measurements, the static pressure behind the windshield and within the balance chamber must at all times equal the pressure at the base of the model.

3. Temperature effects: At M 4 the temperature of the air in the new tunnel's test section is MINUS 327°F. but aerodynamic heating raises the temperature of surfaces (of tunnel walls and of models) by about 350°: to about 20°F. To avoid temperature errors in measurements of forces, pressures, etc., special manometer fluids, special elastic members, special electrical components and other "specials" must be used.

Not only does the tunnels lab solve such problems but it helps develop instruments for flight-testing the new supersonic airplanes and it calibrates them for all required supersonic speed ranges. . . . Naturally!!

The new Flexible-throat Tunnel, dedicated May 17, 1948, is capable of operating at any speed from subsonic to Mach No. 4 (four times the velocity of sound in the gas used—which is absolutely-dry air). Speed can be changed during one test by altering shape of throat.



Test Section of new adjustable-nozzle tunnel (not clearly visible in general view above).

Shape of nozzle is altered by means of powerful jacks, remotely commanded, which bend the steel floor and ceiling plates forming the throat. At M 4, minimum section is ¾ inch; at about sonic speed it is 20 inches; yet accuracy is nearly perfect.

Nozzle-contour accuracy of 0.001" is obtained by a special automatic control system, part of which is shown here.

PICTORIAL EDITORIAL

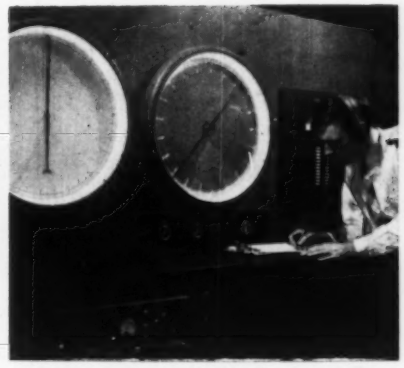
Supersonic-speed Wind-tunnels Facility, Automatic-control Marvel, One Huge Double-barrel Testing Instrument

AVIATION AND BALLISTICS TO BENEFIT FROM DEVELOPMENT SHORT-CUTS IT MAKES POSSIBLE

[Two years ago the Fixed-throat SSWT *(below)* was unveiled. It was featured in technical and news magazines. It was not even mentioned in *Instruments*. When asked why we passed up a big instrument story we replied that it was only half of THE story but, of course, we had to decline to explain. On May 17 the Army unveiled the other half—the upper half structurally, the higher half scientifically! So now, exclusively in *Instruments*, the big story is told in two halves: interpretively on the preceding pages; pictorially on these two.—MFB]

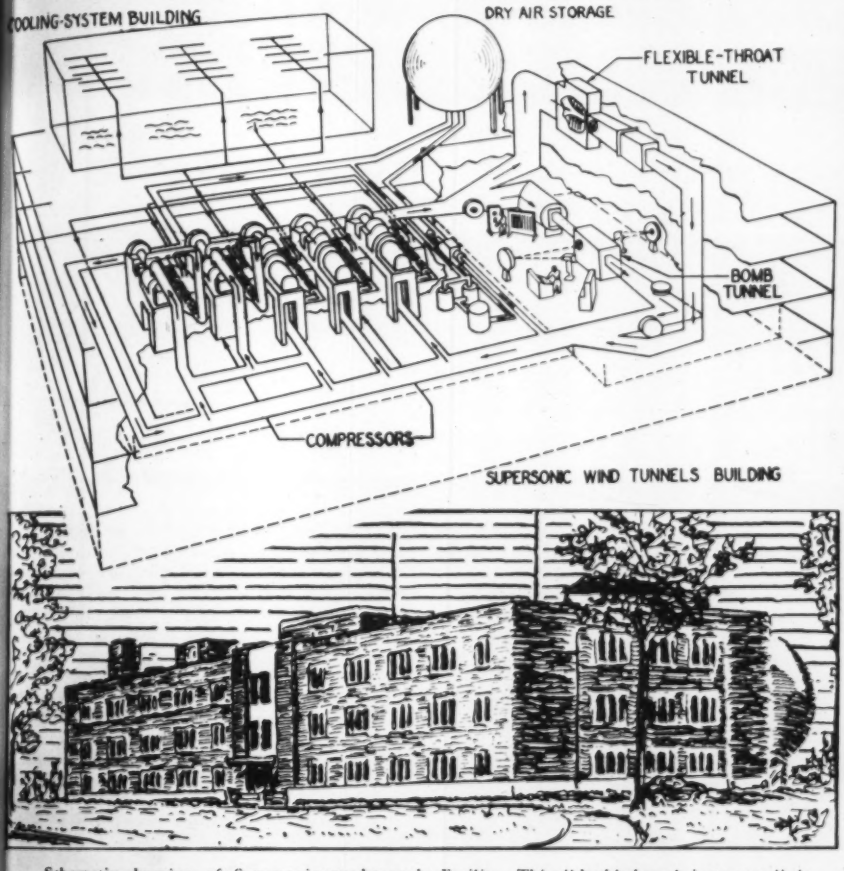
The "older" fixed-throat tunnel is also modern, having been completed late in the war and first used for supersonic testing in 1945. It is equipped with a number of interchangeable nozzles, each providing one subsonic or supersonic speed.

One hundred mercury manometers indicate pressures acting on models.

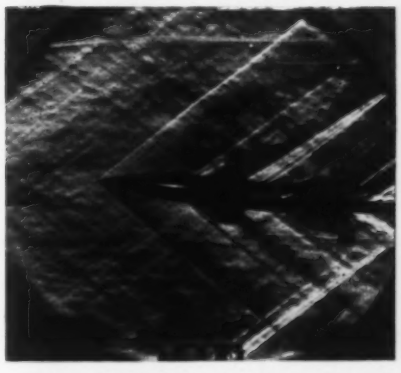


Six-component balance cabinet of FTWT measures forces acting on models.

Schlieren camera for photographing shock waves and other phenomena.



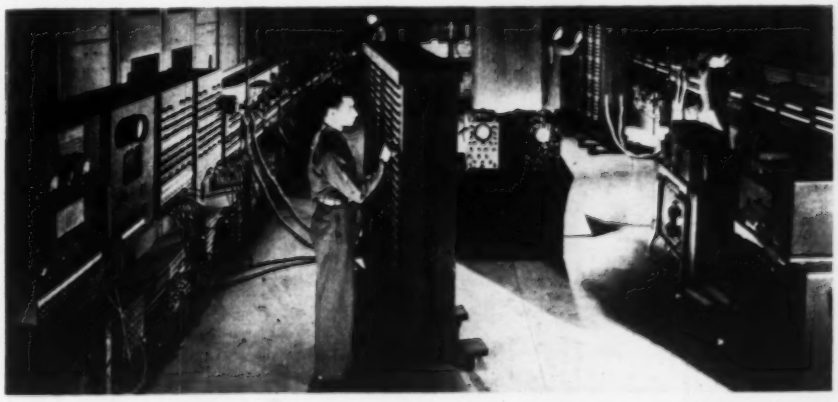
Schematic drawing of Supersonic-speed-tunnels Facility. This "double-barrel instrument" is so huge that two of its parts (cooler and storage sphere) overflow the building proper. This building is the size of a city high-school and has dozens of laboratory and shop rooms.



Schlieren photograph of a model positioned at five-degree angle-of-attack.

Instrument Development Section of Supersonic WT Laboratory constantly meets new requirements for unprecedented measurement techniques. At left, Dr. T. L. Smith.

General view of Compressor Room. Total power is 13,000 hp. Control board at left; for remote-control desk, see front cover.



One of the three large mathematical instruments in the Ballistics Research Laboratory is the ENIAC (illustrated). The others are the EDVAC and the Bell Relay Computer.

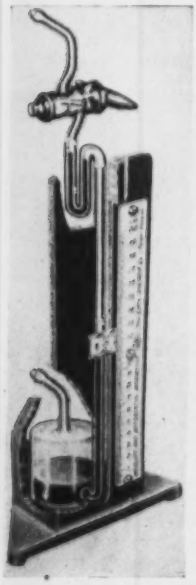
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 567

Dual-purpose Manometer

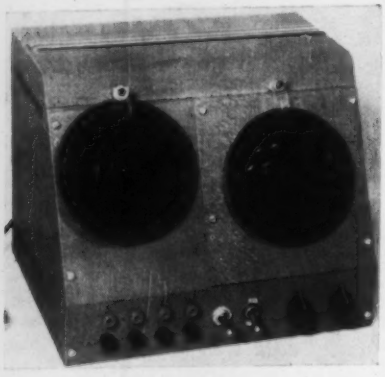
New form of manometer permits making either absolute or differential measurements of pressure and vacuum; reduces task of cleaning and filling. Single reading is required to obtain precise measurement automatically corrected for ambient temperature and reduced to a height of mercury at 0° C. Principle of operation: closed end is effected by means of a U-tube which traps mercury to form vacuum seal and an oblique bore stopcock above trap to hold up mercury seal. For differential readings, stopcock is kept open and connected to lower source of pressure. Ratio of diameters of tube and reservoir is adjusted to counteract increase in mercury height due to its lower density at room temperature than at 0°C. Coefficient of expansion of Vitrolite scale is such that precision of 0.1 mm. is maintained for temperature variation between 20° and 30°C. A vernier is provided to simplify reading to 0.1 mm. Mounted on aluminum stand. Range: 0-200 mm., vernier reading to 0.1 mm.—*Emil Greiner Co., 161 Sixth Avenue, New York.*



Please mention number 601 when filling out card

Servomechanism Performance Analyzer

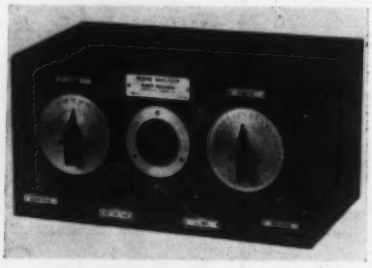
New "Transfer Function Analyzer" measures performance characteristics of servo systems. Amplitude and phase characteristic may be determined with servos using signal frequency of 50 to 800 cps. With data secured, it is then possible to predict whether system is stable, and limits of stability. If system is unstable, the part contributed by each component can be determined. Instrument checks performance of either open- or closed-cycle systems; furnishes output signal from 0 to 17 volts a.c., modulated sinusoidally at any frequency from ½ to 10 cps. A dial calibrated in 1° intervals permits variation of phase modulation envelope from 0 to 360°. Adjustment is provided to permit adjustment of sweep width to desired value. — *Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.*



Please mention number 602 when filling out card

Automatic-control-system Analyzer

New "Servo Analyzer" has been specifically designed to aid development and testing of servomechanisms and automatic-control systems employing 400-cycle error-measuring devices such as Selsyns or "E" type pick-offs. When hooked up to a servo system under test, it provides response data which otherwise could only be obtained by lengthy computations or graphical methods. Frequency response and transfer function may be obtained over an input range of 1 cps. to 60 cps. Analyzer may also be used to obtain equivalent d-c. transfer function of a-c. amplifiers which include damping or integrating networks. Frequency control is said to be stable and accurate to a fraction of a cycle per second.—*Flight Research Engineering Corp., P. O. Box 1-F, Richmond 1, Va.*



Please mention number 603 when filling out card

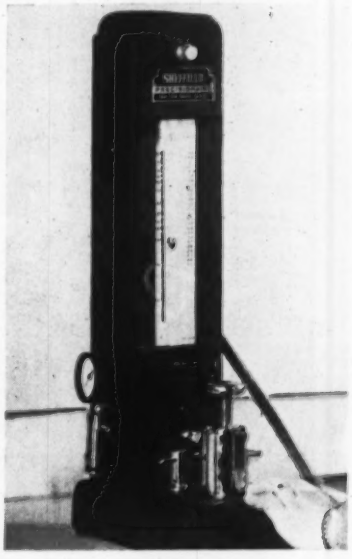
Voltage Regulator

New "Type CVM-1 Constant Voltage Ballast Transformer" protects and stabilizes operation of "G.E. Type UA-4 Mercury Vapor Lamp." Operation of lamp is said to be completely stable, free from effects of varying line voltage and lamp life is increased by preventing over-voltage operation. No moving parts and no maintenance or adjustments.—*Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill.*

Please mention number 604 when filling out card

Fiber Grader

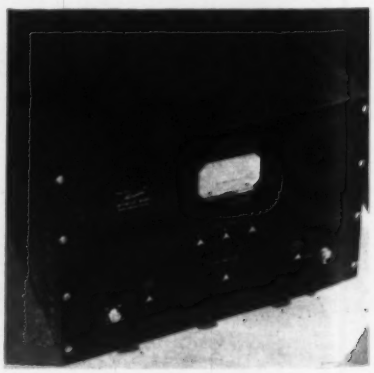
New "Micronaire" measures and classifies fineness of textile fibers (animal, vegetable and synthetic) in a fraction of the time formerly required by laboratory methods and equipment. Two tests per sample can be made in two to three minutes. Repetitive accuracy is within 0.1 micrograms per inch on cotton; higher with other types of fibers. "Micronaire" utilizes principle of forcing air through a plug of fibers and indicating resistance to air flow, which resistance is greater for fine than for coarser fibered stock. Direct readings are made from a scale calibrated in units standard for the fiber being checked.—*The Sheffield Corp., Dayton 1, Ohio.*



Please mention number 605 when filling out card

Self-balancing Wattmeter Bridge

New "Model 123A Wattmeter Bridge" directly indicates microwave power measured by barretter element



over range of 10 milliwatts down to a few microwatts. Range can be extended to 100 watts. Accuracy better than 5% is claimed. No adjustments except zero standardization are necessary because bridge is automatically self-balancing. Average power is read directly in milliwatts. Three ranges, 10, 1.0, and 0.1 mw., are selected by three-position switch. Frequencies at which power can be measured depend only upon barretter mount used. Requires 115 volts, 60 cycles. Weight 45 lbs. Cabinet dimensions 12¼" × 19" × 14¾". Bridge alone is mountable in standard relay rack.—*Sperry Gyroscope Co., Great Neck, N. Y.*

Please mention number 606 when filling out card

Low-flow Rotameter

New "Sho-Rate Rotameter" is for measuring low flows of liquids or gases in purge systems or where flow guide is needed. Packing gland withstands 500 lbs./in.² pressure. Float travel is 3" and maker claims meter is flexible for ready installation. No. 4 tube size is furnished with Pyrex, aluminum, stainless steel, Monel or tantalum float for water rates ranging as high as 4.7 gph. and air rates of 9.0 to 25.0 cfh. Model No. 5 has stainless steel float, water rating 9.0 gph. and air rating 13.2 cfh. No. 6 size, also with stainless float, has flow rate of 24.0 gph. and air, 36.0. cfh.—*Brooks Rotameter Co., P. O. Box 8-5448, Lansdale, Pa.*

Please mention number 607 when filling out card

Two- and Three-dimensional Engraver

New "No. 252" is a portable pantograph machine of unique design, for standard two-dimensional engraving and three-dimensional duplicating. It requires no highly skilled mechanic for its successful use. Engraved work and master copy are right-side-up and in sight of operator. Three-dimensional milling is accomplished by merely tracing shape of an enlarged master with stylus. Three-dimensional pantograph prevents spoiled work due to failure to lift cutter from work before lifting stylus out of master: raising stylus arm automatically lifts cutter from work, also gives unlimited access to work and master copy. Chuck holds midget milling cutters, burrs or mounted points having ⅛" shanks. Micrometer depth control graduated in thousandths of an inch has a range of 0.250" regardless of ratio being used. Standard micrometer spindle is interchangeable with spindles designed for special-purpose work. New engraver is adaptable to a wide range of instrument-shop uses. A complete line of accessories increases its versatility.—*Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.*

Please mention number 608 when filling out card

Multi-purpose Meter

New "Model 10-F Range Master" features built-in fuse and covers 25 ranges. Direct reading on all ranges is

claimed. Size: 8¾" × 7¼" × 4". . . . Shipping weight, 6½ lbs.—*Bradshaw Instruments Co., 348 Livingston St., Brooklyn 17, N. Y.*

Please mention number 609 when filling out card

Indicating and Controlling Pyrometer

New "Simplytrol Indicating and Controlling Pyrometer" is thermocouple type for furnaces, ovens, kilns, etc.

High-resistance millivoltmeter indicator is equipped with platinum contacts that close when set temperature is reached. Contact circuit is interrupted every few seconds but closes again immediately if temperature is still up to control point. Load control switch has 10 amp. rating, 125 volts. Standard ranges available for 0-2500°F. (1370°C.), 0-1500°F. (800°C.) and 0-500°F. (260°C.). Operates from regular 110 or 220 volts a.c. or 110 volts d.c.—*Assembly Products Inc., Main & Bell Sts., Chagrin Falls, Ohio.*

Please mention number 610 when filling out card

Rheostats

New "Vitreous Enameled Round Rheostats" are announced in seven sizes from 50- to 500- watt. Winding of resistance wire or ribbon is uniformly distributed around a ceramic core and is kept in position by a protective coat of vitreous enamel. Core is cemented to base of gray porcelain with heat- and water-resisting cement. Contact arm consists of a channel-shaped center truss spring hinged to copper-graphite contact block holder. Hinge spring assures correct constant contact pressure between contact block winding at all points of sliding path. All live parts are electrically insulated from mounting parts and shaft. Underwriters' Laboratories Approval applied for.—*Rex Rheostat Co., 3 Foxhurst Rd., P. O. Box 232, Baldwin, L. I., N. Y.*

Please mention number 611 when filling out card

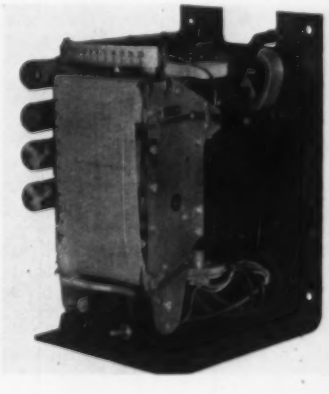
Volt-ohm-milliammeter

New "Model 666-HH Pocket-size Volt-ohm-milliammeter" is described as a "complete, miniature Laboratory for d-c. and a-c. voltage, direct current and resistance analyses." Its many ranges and unique features are said to provide an answer to the volt-ohm - milliammeter requirements of radio servicemen and amateurs, industrial engineers, laboratory technicians, etc. New refinements in design feature: (1) Greater scale readability; (2) simplified switching; (3) trouble-free plug-in connections; (4) greater stability on all a-c.—d-c. voltage and current ranges. New black molded case is completely insulated. Test leads and instructions are furnished.—*The Triplett Electrical Instrument Co., 135 E. College Ave., Bluffton, Ohio.*

Please mention number 612 when filling out card

Photoelectric Recording Wattmeter

New photoelectric recording wattmeter consists of maker's high-speed photoelectric recorder and a newly-designed wattmeter measuring unit; can be used to measure d-c. power or a-c. power up to 10,000 cps.; has a linear scale, is available for portable use or for semiflush mounting. Chart speeds of 0.5 in./hr. to 72 in./min. obtainable by using different combinations of chart carriages and rate gears. When instrument is calibrated for a particu-

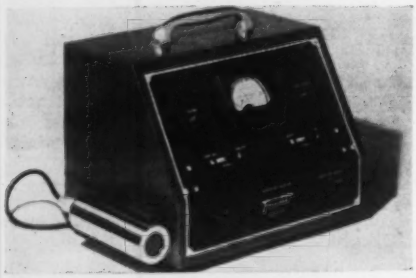


lar frequency, accuracy is ±3%; when calibrated for 60 cycles, it can be used over entire range of 60 to 10,000 cps. at unity power factor with an error of ±5%. Power-factor error when going from 0.5 lagging to 0.5 leading is ±3%. Current circuit is rated either 5 or 10 amperes; potential circuit either 120 or 240 volts. Current and potential transformers can be used to extend this range if necessary. New wattmeter is compensated for frequency and power-factor changes. It is critically damped, and its burden is low because of the use of special magnetic materials.—*Meter & Instrument Div., General Electric Co., 40 Federal St., West Lynn 3, Mass.*

Please mention number 613 when filling out card

Radioactivity Monitor

New "Model SU-3 Laboratory Monitor," a routine contamination monitor in radioactivity laboratories, is a porta-

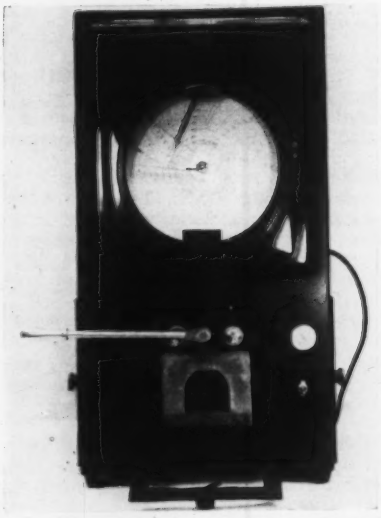


ble a-c.-operated counting rate meter of moderate accuracy (5% on all ranges) with three full-scale ranges of 200, 2000 and 20,000 counts per minute. It comes complete, equipped with a thin mica window (3-4 mg./cm.^{2}) sensitive Geiger tube, enclosed in a probe connected to instrument by a 4-ft. length of shielded cable. In addition to visual indication of counting rate, a built-in loud speaker provides aural measure of activity present. Dimensions: 9" × 12" panel, 9" max. depth behind panel. Weight 17½ lbs. incl. Geiger tube mount.—*Tracerlab, Inc., 55 Oliver St., Boston 10, Mass.*

Please mention number 614 when filling out card

Relaxometer for Elastomers

New "Hi-Po-Log" was developed for accurate measurement of stress relaxation in rubber or plastic-like materials. It permits determining, in one hour, stress relaxation behavior of sample over weeks or months. It comprises a jig having a leaf spring as a platform above which is a cam-operated plunger which descends and compresses a sample placed on leaf spring. Temperature-compensated strain gages mounted on underside of spring transmit minute deflections to an electrical recorder. Jig is located in a small temperature-controlled oven. Adequate space is allowed for temperature conditioning of a number of samples. Samples can be loaded rapidly and load adjusted easily. Record of relaxation under effectively constant deflection is continuous during the measuring time. It is a logarithmic spiral and, when it is replotted on semi-log paper using time as abscissa and ratio of loads as ordinate, resulting curve gives a constant which is characteristic of material tested and can be

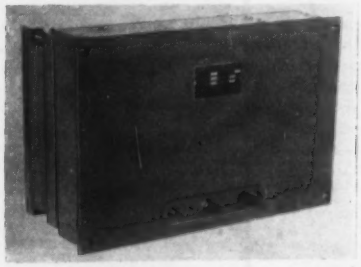


used as a criterion. Instrument measures 16" wide by 31" high by 13" deep and operates on 110-volt 60-cycle a.c.—*W. S. Macdonald & Co., 33 University Road, Cambridge 38, Mass.*

Please mention number 615 when filling out card

A-c., D-c. and R-f. Regulator

New "Controller" employs maker's principle of automatic electronic voltage regulation, permits selective stabilization of a-c., d-c. or r-f. outputs in any one circuit over wide ranges of line and load. Controller's a-c. output swings between 85 and 145 volts automatically adjusting output of user's unit against line and load. Regulation is achieved "by referencing this output back to Controller." New stabilizer provides stabilization at point requiring regulation. For example: If a stabilization is required for only a portion of user's instrument, it can be done by referencing only that portion of circuit back to "controller." At least one watt of power must be made available to "Controller" bridge circuit. In a d-c. application, at least 0.4 amp. must be made available from rectifier filter circuit. One "Controller" unit may stabilize the output of a transformer, regulate a generator field to control its output or selectively regulate a number of d-c. voltages and currents. Input volt-

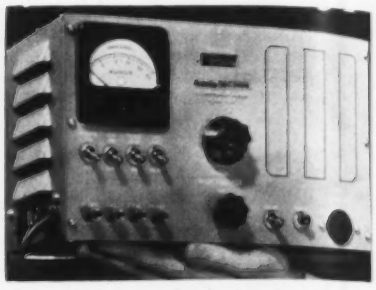


age range, 95-125 (50 or 60 cycles); Load range, 200-2000 va., Regulation accuracy, 0.5% at point of regulation. "Controller" weighs approx. 100 lbs.; is available for relay rack mounting; is fully protected against over-load and over-voltage.—*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*

Please mention number 616 when filling out card

Geiger-Mueller Scaler

New "Model 1000 Decimal Geiger-Mueller Scaler" weighs 11 lbs. An electronic scale of 1000 and a system of true decimal indication make it possible, for the first time in a scaler it is said, to read all counts directly, without interpolation. Counts are shown by a single illuminated number on front panel, with a mechanical register recording thousands (up to 10,000,000)



in easily-read numbers. Scaling is accomplished by three scale-of-ten plug-in decimal counting units. High-voltage power supply is regulated and adjustable from 100 to 2,500 volts. Terminals permit connection of oscilloscope, counting rate meter and a remote count switch. A loudspeaker unit is available for plug-in-operation. Input accessories (Neher-Pickering quenching stage and a tiny probe preamplifier) plus a pre-amplifier stage in scaler cabinet provide complete flexibility in operation. Many new features are based upon recommendations of AEC and on suggestions from scientists engaged in radiation work.—*Berkeley Scientific Co., Sixth & Nevin Ave., Richmond, Calif.*

Please mention number 617 when filling out card

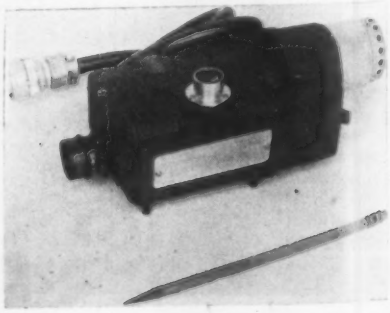
Thermocouple Protection Tubes

New "Metalcarb Thermocouple Tubes" are for high-temperature non-ferrous metals, such as nickel-silver, phosphor bronze, copper, etc. Tube fixture has thermocouple swedged into end to give fast response, and tube is covered by carbofrax to protect tube at flux line. New tubes may be used for semi-permanent immersions.—*Elematic Equipment Corp., 1150 W. Marquette Rd., Chicago, Ill.*

Please mention number 618 when filling out card

Synchronized Aircraft M-p. Camera

New "Syno-Graphic" is an airborne motion-picture camera designed for aircraft flight tests, for use when data

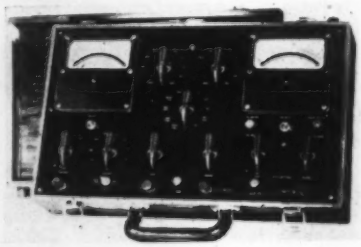


must be not only recorded but also synchronized from two or more sources. The camera uses 16-mm. film in 50' magazines and has shutter speeds ranging from 1/16 to 1/64 second. Lenses may be interchanged in accordance with specific needs by adapter rings. Power for driving film and shutter is supplied by a 400-cycle synchronous motor, coupled by a magnetic clutch. Precision built magazine is said to eliminate stoppages common in this type equipment.—*Flight Research Engineering Corp., Richmond 1, Va.*

Please mention number 619 when filling out card

Multiple-range Tester for Electrolysis

New "Model 5 Multi-combination Meter," designed for electrolysis and corrosion investigations and cathodic protection testing, covers wide range of direct current and potential measurements. High-sensitivity, 300 ohms-per-volt milli-volt/voltmeter covers ranges of 2 millivolts to 100 volts. High-sensitivity, 62,500 ohms-per-volt voltmeter has range of 100 millivolts to 20 volts. Used separately or simultaneously. Meter includes potentiometer-voltmeter with a high-resistance calibrated galvonometer, vacuumtube voltmeter, battery operated, with ranges from 100 millivolts to 10 volts with 500,000 ohms input resistance; milliammeter and ammeter with full scale ranges of 1 milliampere to 20 amperes; and zero-resistance type ammeter with capacity up to 2 amperes. D-c. biasing potential and polarity reversing switch is included. For measuring resistance of shunts, leads, resistors, for measuring soil resistivity, etc. Maker claims "Model No. 5" to be most

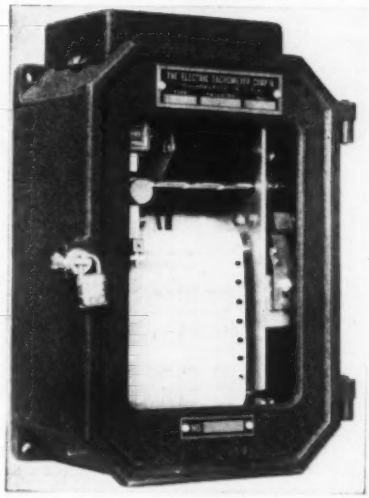


versatile instrument available for highly specialized testing, and takes the place of many separate instruments. Weighs 23 lbs.—*M. C. Miller, 1142 Emerson Ave., W. Englewood, N. J.*

Please mention number 620 when filling out card

Speed and Production Recorder

New "Model R-300-H" speed and production recorder is electrically operated, consists of synchronizing contactor and patented step-by-step motor in recording instrument. A steel stylus marks a wax-coated chart when, at one-half minute intervals, master clock makes contact to disengage feed screw. The same contact feeds chart downward at 2" per hour. This cycle produces a series of parallel lines, the length of which is proportional to speed or production. Recorder produces continuous record of operating speed, showing slightest irregularity, as well as idle time. Guaranteed to have ac-



curacy of 0.5% of full scale.—*Electric Tachometer Corp., 22nd and Vine Sts., Philadelphia, Pa.*

Please mention number 621 when filling out card

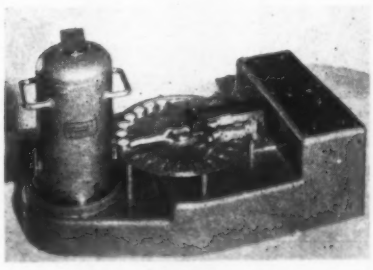
Electrolytic Capacitor

New "Type AVL" electrolytic capacitor, for use wherever high humidity is encountered, is hermetically sealed in hot-tinned steel or copper outer can, with an inner container of aluminum. Terminal lugs also are hot-tinned, straight or with a right-angle bend. Terminals themselves are well insulated with Bakelite bushings. "Type AVL" comes in a wide range of container sizes and capacitances. — *Cornell-Dubilier Electric Corp., South Plainfield, N. J.*

Please mention number 622 when filling out card

Automatized Radioassaying

New "SC-6 Automatic Sample Changer" permits radioactivity measurements on as many as twenty-five samples to be made automatically without attention; results are automatically printed on a paper tape. Instrument can also be used for automatically making half-life measurements on short-half-



life materials or, with minor changes, can be used for obtaining energy spectrum data on a particular sample by automatically placing over the sample absorbers or filters of varying density and thickness and making measurements of the amount of activity detected by the G-M tube. Automatic Sample Changer is one of four required components: (1) Auto scaler for detecting and totalizing radioactive disintegration of sample; (2) Tracergraph Printing Interval Timer for recording on a paper tape the time required for a predetermined number of disintegrations; (3) Lead-shielded Manual Sample Changer with Preamplifier to lower background count and to permit reproducible geometrical relationship between sample and G-M tube mounted in lead shield; and (4) Automatic Sample Changer. Photograph shows Automatic Sample Changer with Shielded Manual Sample Changer mounted on it. Connections for power and amplified G-M tube pulse are made to Autoscaler with a single cable and a second cable connects Automatic Sample Changer with Tracergraph.—*Tracerlab Inc., 55 Oliver St., Boston 10, Mass.*

Please mention number 623 when filling out card

Thin-probe Gauss Meter

New "Thin-probe Gauss Meter" has a probe diameter of 0.052", which permits measurement of flux in small-gap magnets heretofore excluded from the range of this type of measuring

device. Furnished in 2" round Textolite case, with hollow bronze exploring probe protruding from back of case. Scale covers 260°, graduated directly in gausses. New "Gauss Meter Kit" is offered where several instruments of different ranges are required. Contains three standard gauss meters of different ratings, each with its own reference magnet.—*Meter and Instruments Div., General Electric, Schenectady 5, N. Y.*

Please mention number 624 when filling out card

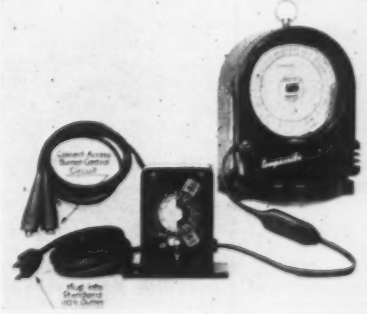
Direct-reading Wet Film Thickness Gage

New models of "Interchemical Wet Film Thickness Gage" are announced in ranges of 2 to 12 mils and 10 to 30 mils, supplementing original model (*Instruments*, March 1948, page 224) with range of 0 to 4 mils and a claimed accuracy of 0.1 mil.—*Henry A. Gardner Laboratory, Inc., 4723 Elm Street, Bethesda, Md.*

Please mention number 625 when filling out card

Timer for Operation Recorder

New "Timer for Tempscribe Operation Recorder" facilitates adjusting fire size of oil burners or input rate of gas



burners. One wire from timer is plugged into lead from "Tempscribe" Recorder; another hooks across control circuit of burner motor, gas valve, or stoker motor. Clock of Timer operates on 100-volt a.c. With this device it is possible to use "Tempscribe" to record burner "on" time at night. After record has been made, timer automatically switches off recorder. — *Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Pa.*

Please mention number 626 when filling out card

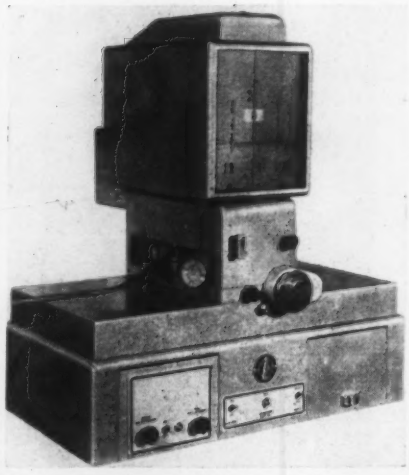
Portable Pyrometer

New "Model 1460 Portable Precision Pyrometer" is a high-resistance type for use with standard thermocouple assemblies; is equipped with large, high-torque pyrometer movement. Instruments are individually calibrated; equipped with knife-edge pointers and long, hand-drawn scales. Can be utilized with standard type thermocouple. Instruments are normally calibrated for the thermocouple and lead assemblies with which they are to be used; are normally provided with automatic cold end compensation.—*Cole Instrument Co., Dept. I, 1320 South Grand Ave., Los Angeles 15, Calif.*

Please mention number 627 when filling out card

Film Comparator-densitometer

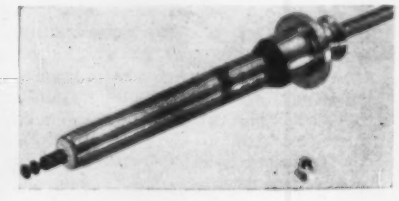
New "Model 5400 Film Projection Comparator-Densitometer" was developed for making comparisons with master films and obtaining transmission readings of spectrum lines photographed on 35 mm. spectrum analysis film. It consists of two film stages for individually moving sample film and master film and bringing them into exact alignment by vernier action. Small portions of each film are projected 20× on a green translucent screen where measurements on scales on screen or comparison with master are easily made. Transmission readings are made by mechanically scanning a line with a 0.0007" slit: light is picked up by a phototube, amplified, and converted into transmission readings by a projection galvanometer. These readings are projected on screen near image of line being measured, thus minimizing operator fatigue. Film stages take any length of sample film and master supplied is 5 ft. long, giving at least 3 lines of all elements detectible from 2100A to 8900A.—*Applied Research Laboratories, 4336 San Fernando Road, Glendale 4, Calif.*



Please mention number 628 when filling out card

Gas Turbine Thermocouple

New "Thermocouple for Gas Turbines" is said to combine high rate of response with excellent life expectancy.

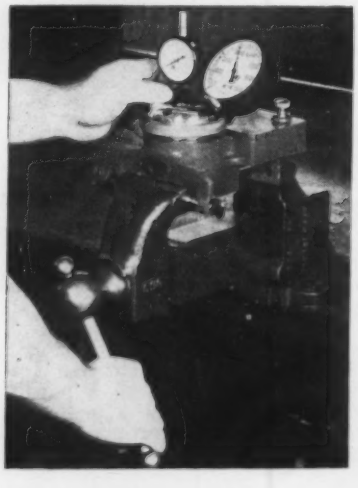


Sensitive portion consists of Chromel tubing into which is inserted and welded an Alumel wire. Time constants of better than 1.2 seconds are measured at gas velocities of 250 fps., with a life expectancy of 200 hours at 1600°F. Inconel sheath, lead wire protected by stainless braid and Chromel terminals are standard.—*Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn.*

Please mention number 629 when filling out card

Sheet Metal Tester

New "Model V" determines ductility or drawing properties of sheet metal; is hydraulically operated in somewhat the same manner as maker's large motor-driven "Model G"; will test material up to 1/16" thick; weighs 20 lbs. complete.—*Detroit Testing Machine Co., 9390 Grinnell Ave., Detroit 13, Mich.*



Please mention number 630 when filling out card

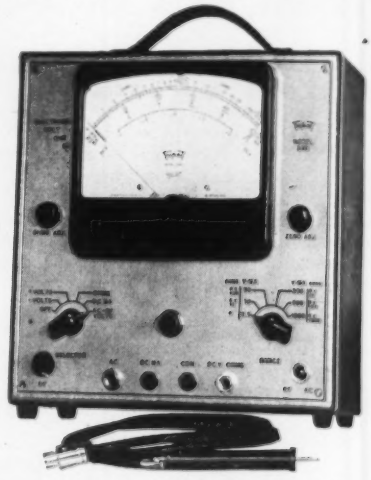
Anti-vibration Mounting

New "Shockmount" is designed to control shock, isolate high-frequency vibration and reduce noise transmittance to the floor. It is a heavy-duty mounting, with load capacities up to 7500 lbs. per mount. Company claims that it reduced need for massive foundations to achieve inertia, and permits placing instruments near machines so mounted. Features: low construction (1-3/16" high); easy installation; rugged 3/16" steel construction; top plate contour limits movement and sheds oil and dirt; flexing element is oil-resistant synthetic rubber.—*Lord Mfg. Co., 1635 W. 12th St., Erie Pa.*

Please mention number 631 when filling out card

Volt-ohm-milliammeter

New "Model 2451 Volt-ohm-Milliammeter" is said to eliminate cumbersome operation of switching back and forth from range to range to balance circuit. All that is required is to zero the instrument on range to be used and proceed with test.—*The Triplett Electrical Instrument Co., 135 E. College Ave., Bluffton, Ohio.*



Please mention number 632 when filling out card

Hydrogen Purifier

New "Deoxo Hydrogen Purifier" removes traces of oxygen by catalytic action from cylinders of compressed hydrogen. Consists of metal cylinder containing platinum catalyst and fittings for attaching to reducing valve on hydrogen cylinder. Operates efficiently at gas flow up to 5 cu. ft. per hr. and at pressure as high as 50 lbs./in.². Catalytic action takes place at room temperature. Purifier is recommended wherever any oxidizing action in reducing atmosphere of hydrogen would be objectionable.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Please mention number 633 when filling out card

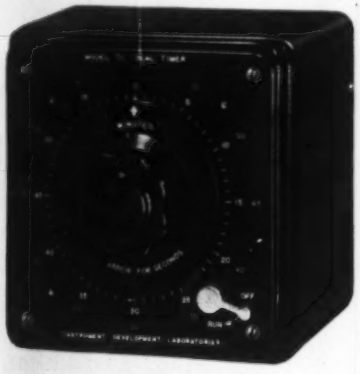
Temperature-compensated Conductivity Cells

New measuring and pre-filled reference conductivity cells which provide for automatic temperature compensation are designed for continuous recording or for automatic control systems where temperature variations of the electrolyte make conductivity measurement difficult. Of heavy-walled Pyrex construction and completely protected by "Type 316" stainless steel sheaths, new cells are provided with standard pipe thread fittings for mounting in pipe lines or through tank walls. Operating conditions may include corrosive solutions, temperatures up to 150°C. and pressures up to 50 lbs./in.^{2}.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Please mention number 634 when filling out card

60-sec.-dial Automatic Timer

New "Model T1 Dual Timer" will either break an electric circuit after a pre-set number of minutes and seconds, or will show elapsed time for an operation. It can be set for any interval from two seconds to 60 minutes. Calibrations



on dial indicate one second, but it is claimed that time values as small as ¼ second can be accurately controlled by interpolating between divisions. Case size, 4½" cube.—*Instrument Development Laboratories, 229 West Erie Street, Chicago 10, Ill.*

Please mention number 635 when filling out card

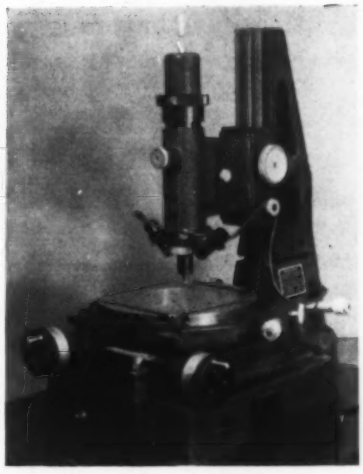
Air Filter Combination

New filter, separator, and trap for filtering compressed air removes 98% of entrained moisture and oil in liquid form. Maker claims automatic release of water saves and insures dry air because water and oil cannot build up in housing to a point where air backs it up and throws it into filter medium.—*Leland Instrument Co., 520 E. Larned St., Detroit 26, Mich.*

Please mention number 636 when filling out card

Spotting Attachment

New "M2001SA2" spotting attachment is for use in laying out drill jigs, templates, etc. Mounts on support arm of maker's Toolmaker Microscope in place of standard optical system. Consists of 25× microscope facilities for mounting and spinning spotting tool. Any number of points may be quickly spotted simply by moving object appropriate distances by means of mechanical stage. Reticle consists of concentric

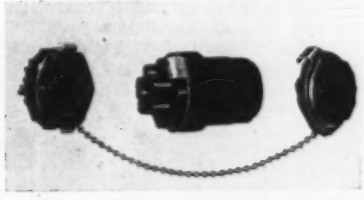


circles interrupted at 90° intervals.—*Gaertner Scientific Corporation, 1201 Wrightwood Avenue, Chicago 14, Ill.*

Please mention number 637 when filling out card

High-voltage Connector

New weatherproof 6-contact high voltage miniature connector for aircraft, industrial and communication equipment, etc., has molded parts of

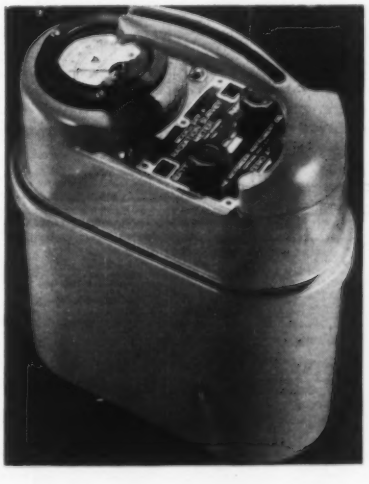


Melamine. Contacts are precision machined and silver-plated. It is impossible to make contact except in proper position. Center contact is "make-first break-last" and provides additional safety when grounded. Positive spring lock prevents accidental disconnection due to vibration. Breakdown voltage is 7000 volts d.c.—*Winchester Electronics Co., 6 East 46th St., New York 17, N. Y.*

Please mention number 638 when filling out card

Gamma-type Radiation Survey Meter

New "247A" gamma ray survey meter is for application where problem requires a field survey rather than lab-

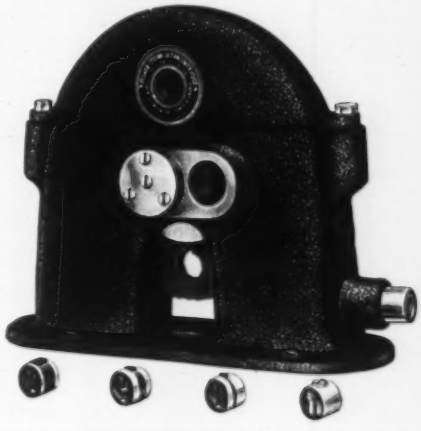


oratory research. It is of ionization chamber type and is said to combine stable operation with extremely rugged construction. Four ranges of sensitivity are provided and instrument is calibrated to read in roentgens over full-scale readings of 2.5-25-250 and 2500 milliroentgens per hour. Case is watertight and both meter and ionization chamber are hermetically sealed. A unique eccentric range switch features a color code to give visual indication of range at which meter is set. Die castings have been used wherever possible to assure ruggedness required. Handle permits easy balance; total weight is 11¾ lbs.—*Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

Please mention number 639 when filling out card

26000-G Centrifuge

New "Fisher-Stern Ultracentrifuge," said to be "a major contribution to instrumentation," develops speeds up to 20,000 rpm. at an air pressure of 80 lbs./in.^{2} and at top speed produces a force 26,000 times that of gravity. It is said to be the first commercially avail-

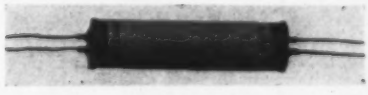


able instrument of moderate cost for this purpose. It effects sedimentation of molecules having a molecular weight of one million or more. It incorporates a Lucite rotor with notched edges that are spun by air pressure. In use, a sample is placed in a cell holder which in turn is inserted in the rotor. Four types of sample cells are furnished for various kinds of analytical work. One (termed "micro-separation cell") permits segregation of precipitated particles for later study. Also available is a photoelectric tachometer for use with this Ultracentrifuge, and a Camera-Base Assembly by means of which photographs can be taken while sample is in motion.—*Fisher Scientific Company, 717 Forbes Street, Pittsburgh 19, Pa.*

Please mention number 640 when filling out card

Resonant Relays

New "Type 182" hermetically-sealed resonant relays are recommended for low-level circuits where change in leak-



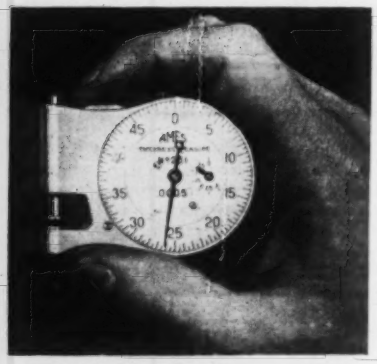
age resistance might be important; operate only when energized at predetermined frequency; employ vibrating-

reed mechanism at seven frequencies from 153 to 442 cps. Wide-band type has 500-ohm coil, operates from 3-volt input; one side of "operate" curve falls in range −2% to −5% from rated frequency and other side from +2% to 5%. Narrow-band type curve, from ½% to 3%.—*Stevens Arnold, Inc., 22 Elkins St., South Boston, Mass.*

Please mention number 641 when filling out card

Thickness Gage

New "Dial Thickness Measures" include two 0.0005"-graduated models with simple "O" adjustment and fixed

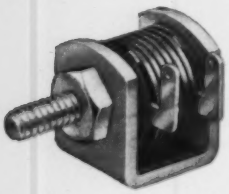


parallel contacts. Suited for accurate measuring of tissues, cellophane, membranes, fibres. Direct-reading count hand permits fast readings anywhere within 0.3125" (5/16") range of the gage. In addition to two 0.0005"-graduated models (0-40 and 0-50), there is a 0.001" model having dial numbered 0-100; also a metric model graduated in 0.01 mm., dial numbered 0-100, with a range of 8 mm.—*B. C. Ames Co., Waltham 54, Mass.*

Please mention number 642 when filling out card

Selenium Rectifier

New "Model SE-14P-6H" miniature selenium rectifier, ½" × ½" × ⅝", is designed for use on low-current applications such as TV preselectors, pre-amplifiers, relays, etc. Rated 110-125 volts a.c. rms., 20 ma. d-c. continuous. Mounts on single 6-32 screw, ⅜" long.



Completely sealed, it features new spring U bracket construction for reliable operation over wide temperature variations.—*Bradley Laboratories, Inc., 82 Meadow St., New Haven, Conn.*

Please mention number 643 when filling out card

Projection Lightmeter

New "Model 8PH12" portable projection lightmeter, which flashes light measurements on a screen for easy reading by large audiences, is designed primarily to simplify problem of distinguishing between adequate and inadequate lighting; is believed to be the only instrument of its kind now on the market. Weighing 8 lbs. and easily operated, it consists of three major parts—a hand-size light-cell probe; a d'Arsonval-type self-contained micro-

ammeter made especially for projection purposes; and a standard SVE 100-watt 2" × 2" slide projector. Normal range of instrument is 0-100 foot-candles; for higher intensities, multiplying masks, furnished in 10 and 100 × sizes, must be fitted over light cell.—*Meter & Instrument Div., General Electric Co., 40 Federal St., West Lynn 3, Mass.*

Please mention number 644 when filling out card

Bunsen-burner Lighter

New "Irving Liter" for Bunsen burners is flint-type lighter which attaches to Bunsen-type gas burners, enabling user to light gas flame without using match. Operates with one hand, ready for instant use. Fits burners of ⅜ to ⅝-inch o.d.—*W. M. Welch Scientific Co., 1515 Sedgwick St., Chicago, Ill.*

Please mention number 645 when filling out card

24-hr.-dial Time Switch

New "Type T-47" time switch, rated 35 amperes at 115 and 230 volts, is timed and operated by synchronous

self-starting, permanently-lubricated Telechron motor. Switch performs one "on" and one "off" operation during any 24-hour period and will continue to do so daily without adjustment. Switch has s-p. s-t. mechanism with silver snap-action contacts. Operation can be manual or automatic. Adjustable clamps set switch for automatic operation at minimum setting of five minutes and a maximum setting of 22 hours.—*Meter and Instrument Div., General Electric Co., Schenectady 5, N. Y.*

Please mention number 646 when filling out card

Group Audiometer

New "4CA Audiometer" permits accurately testing the hearing of one to forty persons at a time, includes several special features suggested in a recent survey of school authorities and members of leagues for the hard of hearing. All necessary parts pack neatly into two cases, only one of which is required when group to be tested numbers ten or fewer. Neither external power sources nor electrical outlet being required, instrument can be used in any location. Operation is as simple as that of an ordinary home phonograph. Each person wears an individual headset which delivers sound from a specially-made phonograph record. Hearing of each person is individually analyzed (left and right ears

separately). Simplified test charts with instructions prevent confusion and error. A monitoring jack permits operator to listen in while all regular receivers are in use. An adaptation permits doctors to use "4CA" to perform individual speech intelligibility tests. New feature is output meter for calibration before each test.—*Western Electric Co., 195 Broadway, New York 7, N. Y.*

Please mention number 647 when filling out card

Electrical Indicating Instruments

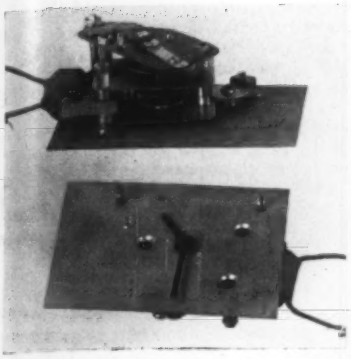
New "Type DO-71" 3½-inch panel instruments are of internal-pivot design, for radio, power supplies, transmitters, amplifiers, and aircraft. Said to have better readability and to eliminate arc lines and distracting printing from scale. Employs a lance-type pointer and large, clear numerals. Internal-pivot construction of new instruments

materially reduces their depth behind panel. Alnico magnet provides quick response and good damping so that moving system follows current or voltage changes rapidly. Larger-radius pivots result in increased resistance to shock and vibration. Large clearance in air gap between pole faces and core minimizes possibility of stickiness normally resulting from collection of dirt and foreign particles in air gap under adverse conditions.—*Meter and Instrument Divisions, General Electric Co., Schenectady 5, N. Y.*

Please mention number 648 when filling out card

Automatic Timer

New "Selectron Timer" designed for instrumentation uses, has a single-circuit double-throw switch with a capa-



city of 1,000 watts and can be used on any electrical unit to either turn ON or turn OFF. Clock movement is a precision made unit, electrically driven with a high-torque self-starting motor. Front panel of clock can carry a dial, and knobs are available for setting the timing mechanism from front panel. Electric switch has positive action that allows user to predetermine a timing action at any 15-minute interval.—*Arnold Clock Corp., 136 W. 52d St., New York 19, N. Y.*

Please mention number 649 when filling out card

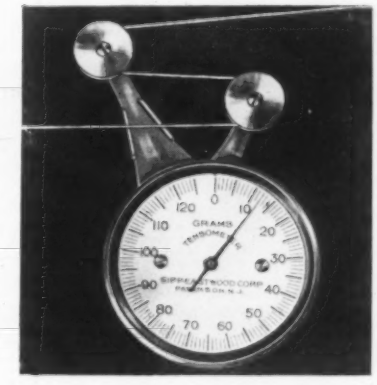
Millimicroammeter

New "Type WV-84A" ultrasensitive microammeter can measure direct currents to one billionth of an ampere and up to one thousandth of an ampere, representing a range of 1,000,000 to 1. Six range settings permitting a choice of the most convenient range. Battery operation makes instrument independent of any external power source. "Burnout-proof" design makes it capable of withstanding overloads of 10,000% without damage to movement. By adding suitable external multiplier resistors, new microammeter can be converted to an extremely high-resistance voltmeter: on lowest range, input resistance of 100 megohms per volt, hence unusually low current drain, as well as extreme stability. It can also be used as a high-range ohmmeter when connected to a suitable power supply. For example, with a 45-volt battery, it will measure resistances as high as 4500 megohms. Voltage drop for full-scale deflection is ½ volt for all ranges. By suitable circuit design, grid current of input tube has been reduced to less than 0.001 microampere. Therefore, current for full-scale deflection depends only on resistance of internal shunts (on lowest range, 50 megohms; on succeeding ranges, reduced in 10-to-1 steps until on highest range it reaches 500 ohms). Selector switch opens battery circuits when in "off" position; also functions as a polarity-reversing switch to obviate need for reversing leads. *Tube Dep't, Radio Corp. of America, Camden, N. J.*

Please mention number 650 when filling out card

Tension Indicator

New "Tensometer" is said to ascertain instantly amount of tension on light wire, yarn, thread, etc. Slips easily into pocket.—*Sipp-Eastwood Corp., Keen & Summer Sts., Paterson, N. J.*



Please mention number 651 when filling out card

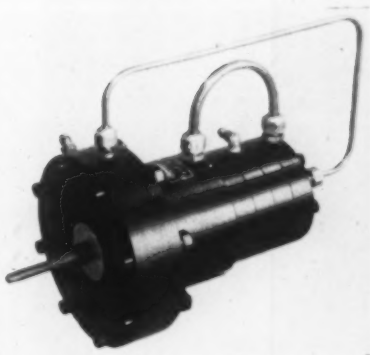
Thermocouple Extension Wires

New thermocouple extension wires have thermoplastic insulation, providing advantages partly due to physical and chemical characteristics of thermoplastic and partly due to type of extension wire construction made possible by its adoption. Color-coded thermoplastic insulation is applied directly over each individual conductor (thickness 1/64"). Secondary insulation comprises a cotton braid applied over both conductors and impregnated with a weather-proof saturant. Result is that 14 B & S gage thermoplastic extension wire has over-all dimensions of 5/32" × 7/32". Performance of thermoplastic extension wire under adverse operating conditions is said to be definitely better than that of rubber. Results of extensive tests covering such conditions are tabulated in announcement. Tables show resistance of thermoplastic extension wire to sunlight, mildew, fungi, molds and weathering; also temperature test results, etc., all in detail.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Pa.*

Please mention number 652 when filling out card

Precision Pneumatic Power Unit

New "Micropositioner" power unit is designed for positioning accurately over small distances in accordance with received pneumatic pressures and is capable of exerting considerable force. As an example, makers explain, new unit, employing a pneumatic pressure of 60 lbs./in.^{2}, can position a lever within approx. 0.003" over a range of 0 to 0.500", working directly without use of mechanical linkage. Successful test applications indicate that "Micropositioner" is well-suited for positioning oil-burner tips, injection nozzles, governor gear, etc.—*Hagan Corp., Hagan Bldg., Pittsburgh 30, Pa.*



Please mention number 653 when filling out card

Quick-change Alloy Scales for Direct-reading Spectrometer

New recording system greatly extends range of application of "Quantometer" direct-reading instrument for spectrochemical analysis (see *Instruments*, March 1946, page 168). It employs removable plastic panels fitted with direct-reading scales for each element being determined, allows panels to be made up for each type of alloy. With this arrangement, instrument can be set up for analysis of any alloy of a certain base metal in a few minutes. (This allows a producer of aluminum alloys, for instance, to analyze samples as received in three or four minutes, even if one is 75S with relatively high zinc, the next 24S with considerable copper and the next relatively pure aluminum.) Change of scales is necessary because high zinc and copper contents affect determination of the eight or ten other elements. New device automatically corrects for these effects and thus allows utmost accuracy on a speed analysis basis.—*Applied Research Laboratories, 4336 San Fernando Road, Glendale, Calif.*

Please mention number 654 when filling out card

Molecular Still

New "Type CMS-5 Centrifugal Molecular Still" is recommended for distilling fats, oils and waxes. Employs centrifugal evaporator said to have unique distinction of operating with least danger to substance under distillation. Conical rotor is 5" in diameter and is warmed by imbedded heater. Condenser is formed by flattened surface of

bell-jar which encloses complete unit. Distillant is in contact with evaporator for only 0.2-0.05 seconds. Normal operating pressure is 0.1-10 microns, achieved and maintained by fractionating oil diffusion pump. Samples of two liters or less may be handled.—*Distillation Products, Inc., 755 Ridge Road West, Rochester 13, N. Y.*

Please mention number 655 when filling out card

Multiple-channel Photoelectric Counting System

New system for counting small parts at high speed for packaging and inventory, employs ten photoelectric detectors operating in parallel and connected to maker's "High Speed Electronic Counters." Circuits are designed to resolve simultaneous or random counts in ten channels. Counter will register count of each part even though ten parts fall past the ten photoelectric detectors at the same instant. A simple feeding mechanism consisting of shake tables or conveyor belts divided into channels can be used to feed at low speed while counting is accomplished at high rates. Photoelectric detectors respond to changes in light level as small as 20%: complete interruption is not required. Through use of maker's "Predetermined Electronic Counters" which reset instantaneously and automatically, packaging processes can be fully automatized.—*Potter Instrument Co., Inc., 136-56 Roosevelt Ave., Flushing, N. Y.*

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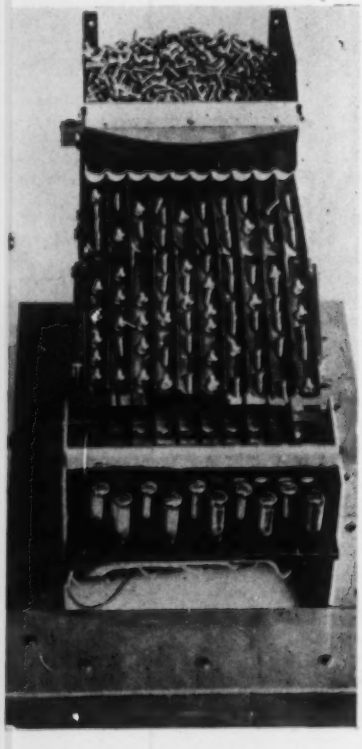

Magnetometer

New "Scout Magnetometer," especially designed for reconnaissance and mining surveys, has a sensitivity of 25 gammas per scale division and a scale range of 3000 gammas; is exceptionally small and light. Equipment consists of tripod with turntable, orienting compass, magnetometer with system, two compensating magnets and necessary field tools. Total weight in carrying cases ready for field use, 20 lbs. "Scout Magnetometer" is operated in same manner as maker's standard Vertical Magnetometer. When equipped with a surveying compass, stations can be rough surveyed without need of additional instrument equipment. This makes new magnetometer particularly adaptable for reconnaissance in areas inaccessible by mechanical transportation.—*Rusba Instrument Corp., 4607 Montrose Blvd., Houston 6, Texas.*

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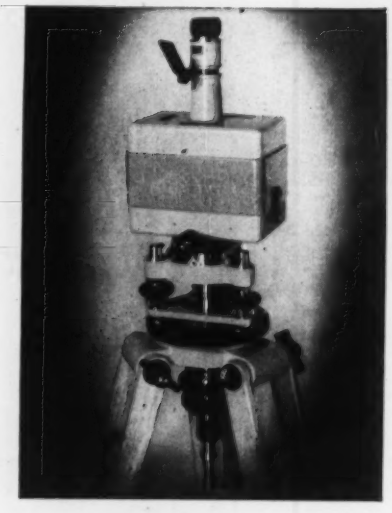

Two-way-movable Apparatus-support Connector

New "Multi-clutch Connector" permits mounting laboratory apparatus on a support frame so that apparatus can be moved vertically or horizontally during the course of a procedure. It attaches to two adjacent ½" rods so that it will slide along the two rods and can be secured at any point by means of a thumbscrew. Openings are provided in new connector so that clamps, upper rods or supports can be held by it.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Please mention number 658 when filling out card

Time Switches

New heavy-duty time switches have fully-enclosed hysteresis-synchronous, low-speed motor said to achieve higher torque both in starting and synchronous operation. New replaceable bearing system is lubricated with silicone product unaffected by temperature. Minimum time between settings of "off" and "on" periods is 90 minutes. Time intervals between "on" and "off" is 30 minutes.—*Sangamo Electric Co., 1022 Converge Ave., Springfield, Ill.*

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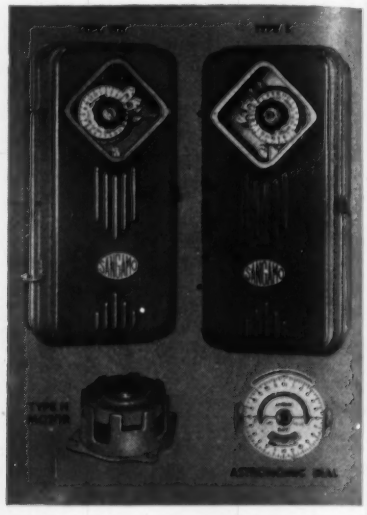
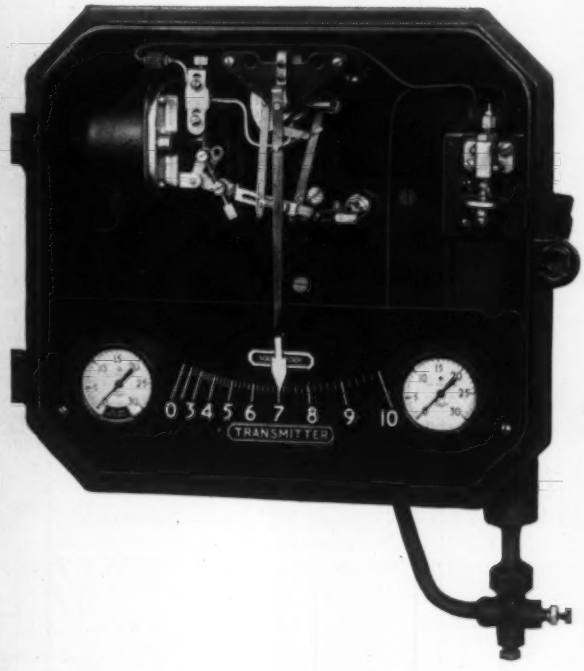


Distortion and Noise Meter

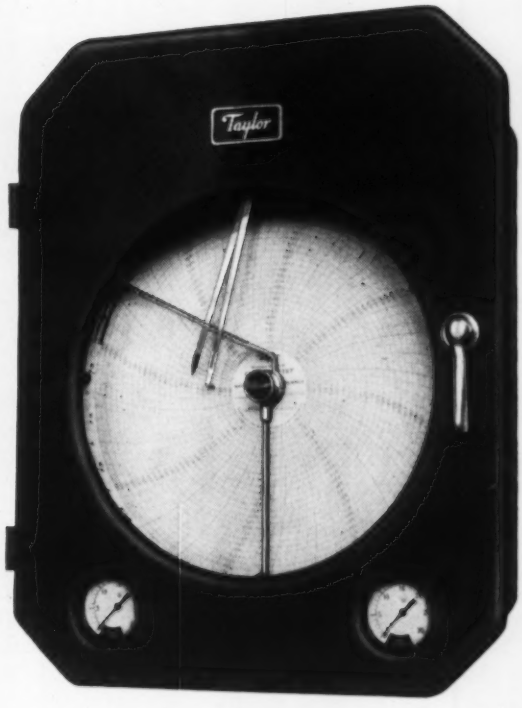
New "Type YDA-1" distortion and noise analyzer, for broadcast, television, research, and developmental applications, combines four basic functions: it measures percentage distortion down to 0.1%; measures hum or noise present on an audio signal; acts as a high-sensitivity VTVM; performs as a frequency meter over range of 50-15,000 cps. Noise range: +2 to −80 db (referred to milliwatt on 600 ohms). Noise frequency bandwidth: 30 to 30,000 cps., on 600 ohms balanced input, and 30 to 75,000 cps. on 100,000 ohms unbalanced input. Accuracy is 5% of full scale. When used as a VTVM, same db range is used, corresponding to inputs between 1 volt and 80 microvolts.

Something Pneu

in Pneumatic Transmission!



This is the transmitter:
Taylor 226R Pneumatic Transmitter



This is the receiver:
Taylor Fulscope Recording Controller

YES, it's the "pneu"est thing out! Yet this new Taylor Pneumatic Transmission System has been thoroughly field-tested and you can count on it keeping every process in your plant right at your fingertips—accurately within ½ of 1% scale range!

It consists of the two instruments shown above, a new Taylor 226R Pneumatic Transmitter connected by a pneumatic lead line to a Taylor Fulscope Recording Controller on your central control panel. You don't have to walk a step farther than that to check chart records or indications. And you can have constant remote control, record or indication of rate of flow, liquid level, temperature, or pressure.

226R Transmitters are available with all forms of actuation for single or double duty, indicating or recording, or as single duty transmitter-controllers with any of the 5 standard types of Fulscope Control. If transmitter adjustment is ever required, it's accomplished by two conveniently located micrometer screws—one for range and the other for zero setting.

Ask your Taylor Field Engineer for full details. Also ask him about "Transet"—our new transmission system that eliminates time lag and cuts panel space to one third. Write for Bulletin 98156. Taylor Instrument Companies, Rochester, N.Y., and Toronto, Canada.

▼ ▼ ▼

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.

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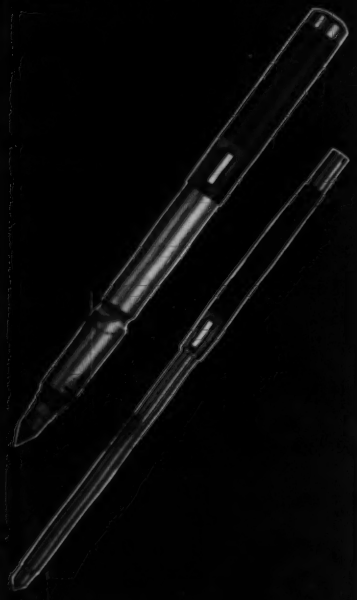
GALVANOMETERS

Available with natural frequencies from 15 c.p.s. to 1500 c.p.s., electromagnetically damped and to sensitivities as high as 2" per microampere at 1 meter focal distance.



CENTURY TUBULAR TYPE GALVANOMETERS

The Model G-14 in hard chrome plated brass tube and the Model 205 of heat-treated, non-magnetic stainless steel. Rugged and durable, yet possesses extreme sensitivity. Internal suspensions are manufactured by a patented process which provides unequaled balance. Hermetically sealed giving maximum efficiency under all climatic conditions.

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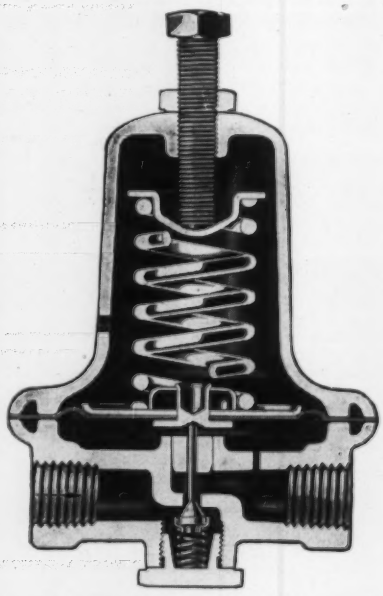
World's Largest Manufacturer of Geophysical and Special Galvanometers

Accuracy and bandwidth are the same as for noise measurements.—*Specialty Division, General Electric Co., Electronics Park, Syracuse, N. Y.*

Please mention number 660 when filling out card

Gas Pressure Regulator

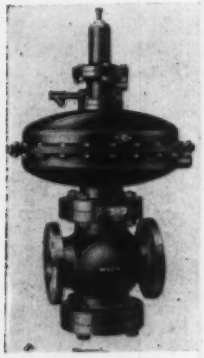
New "Type 67 Small-volume Reducing Valve" is a self-contained regulator for air or gas. Provides close pressure maintenance on applications such as instrument air supply service and panel pneumatic loading for remote hand control. Capacity, up to 6 cfm. at 100 lbs. inlet, 5 lbs. reduced pressure. Reduced pressures, 3 to 20; 15 to 40; 25 to 75 lbs./in.^{2}; initial pressures, 250 lbs., 150°F. maximum.—*Fisher Governor Co., Marshalltown, Iowa.*



Please mention number 661 when filling out card

Gas Pressure Regulator

New "5000 Series Pressure Loaded Supersensitive Gas Regulator" controls pressure within a fraction of an inch water column even with large variations in flow. May be used on either reducing or back pressure service for any control pressure up to 100 lbs./in.^{2}. Fluid pressure from outlet side is applied to under side of a large-area diaphragm. Loading pressure from integral pilot is applied to the upper side of the diaphragm. Opening of fixed orifice determines sensitivity of control.



This construction eliminates springs and packing gland. Large-area diaphragm cases are 3/16" steel stampings as standard construction. Lower steel diaphragm case is welded to a forged steel flange which is piloted into and bolted to valve body, minimizing valve height. Travel stops are provided. Valves are available in sizes from ½" to 12".—*Hammel-Dahl Co., 242 Richmond St., Providence 3, Rhode Island.*

Please mention number 662 when filling out card

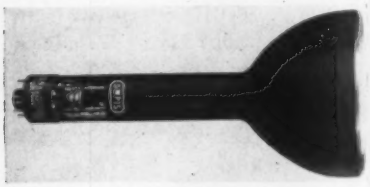
Indicating Temperature Controller

New Indicating Temperature Controller for mechanical convection type ovens, liquid baths, molding dies, etc., applies response motion of a liquid-filled bulb-and-bellows assembly to a snap-acting switch. Any of numerous standard remote bulb assemblies may be used. A thumb-screw in top of case permits upper indicating pointer to be set at any desired temperature cut-off point. Dial may be read easily from ten or twelve feet. Overall dimensions of case, 5½" × 5½" × 1¾"; weight, 3 lbs. Adjustable mounting lugs for either flush or surface mounting. Standard model is fitted with a copper bulb assembly; however, other assemblies in stainless and mild steel are available. Two standard ranges: +50°F. to +350°F. and +50°F. to +600°F. Special ranges between limits of −120°F. to +600°F. Standard differentials available are from ½°F. in circulating liquid to 2°F. in air. Switch ratings of 10 amp. 125 volts a.c. and 5 amp. 250 volts a.c.; other load ratings available.—*United Electric Controls Co., 85 School St., Watertown, Mass.*

Please mention number 663 when filling out card

Flying-spot Cathode-ray Tube

New "Flying-spot Cathode-ray Tube RCA-5WP15" enables television stations to employ flying-spot, video-signal generator which permits telecasting of individual station call letters and test patterns from interchangeable slide transparencies or from opaque surfaces.—*Tube Dep't, Radio Corporation of America, Harrison, N. J.*

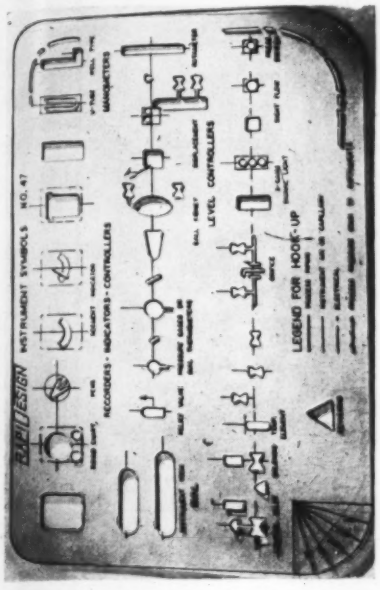


Please mention number 664 when filling out card

Instrument Symbols Template for Draftsmen

New "No. 47 Instrument Symbols Template" for design personnel and draftsmen is particularly adapted to

layouts where liquid level, differential pressures and flow instruments are used. Schematic diagrams of recorders, indicators, controllers, valves, manometers, etc., are quickly and easily con-



structed. Template is made of clear, 0.040" mathematical-quality plastic with printing on reverse side to prevent wearing off. All cut-outs are beveled to permit sharp delineation. Template is 5" × 8"; has a 90° protractor and a dotted-line radius guide.—*Rapidesign, Inc., P. O. Box 592, Glendale, Calif.*

Please mention number 665 when filling out card

Control Relay

New "Leveltronic Relay" is for industrial applications where pressure, liquid and temperature control is required. Circuit is of positive-acting thyratron type with tube current limited to less than 1/3 its maximum value for long life and low maintenance. Two

models cover a range of 20 ohms to above 2 megohms with continuously-variable sensitivity giving 2 to 1 discrimination over full range. Circuit is stable over a wide range of voltage fluctuations. Relay has d-p.d-t. action with contacts for ½-hp. motor. Direct- and reverse-acting units are available. Construction is in accordance with NEMA standards, with low-voltage (6 volts) control circuit completely iso-

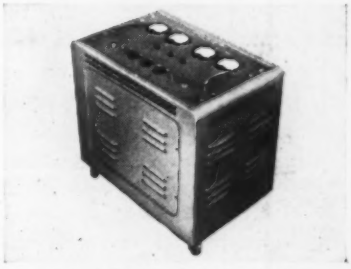
Regulated POWER SUPPLIES

THESE G-E Regulated Power Supplies provide a quick, reliable source of constant d-c voltage. Clean, economical and space-saving, they eliminate the need for expensive batteries that require continuous care, and will prove an indispensable aid in laboratory and production work.

POWER REQUIREMENTS: 105-125 volt, 60-cycle commercial power. Power input 350 watts maximum.
OUTPUT POWER: 250-450 volts d-c (either negative or positive terminal may be grounded as desired). 300 milliamperes maximum.
IMPEDANCE: Approximately 2 ohms at 30 cycles sec. Decreases with increasing frequency.
RIPPLE: Less than (.005) volts, peak to peak.
LOAD REGULATION: Less than 1 percent change in output voltage from no load to full load.

TYPE YPD-2
Range 250—450 Volts

POWER REQUIREMENTS: 105-125 volts, 60-cycle commercial power. Power input, approximately 375 watts.
OUTPUT POWER: 250-400 volts d-c, 200 milliamperes individually from two separate supplies, or 250-400 volts d-c, 400 milliamperes from both supplies when operated in parallel.
RIPPLE AND NOISE: Less than 0.020 volt rms.
LOAD REGULATION: One percent or less change in output voltage from no load to full load, or for line voltage variation from 105 to 125 volts.



TYPE PS-4 (Dual Regulated)
Range 250—400 Volts

POWER REQUIREMENTS: 105-125 volts, 60 cycle commercial power. Power consumption approximately 800 watts at full load.
D-C OUTPUT: 0.125 ampere from 160 to 1500 volts output.
RIPPLE: Maximum 0.05 volt (peak to peak value).
LOAD REGULATION: 0.15 percent or less change in output voltage from no load to full load at any power line voltage and output voltage within rating.
LINE REGULATION: Less than 0.015 percent output voltage change per volt change in line voltage over specified range.
IMPEDANCE: Less than 10 ohms at 1500 volts and less than 2 ohms at 160 volts output.

TYPE YPD-4
Range 160—1500 Volts

For additional information concerning these units and other precision equipment write: *General Electric Company, Electronics Park, Syracuse, New York.*

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Make your tedious weighing job

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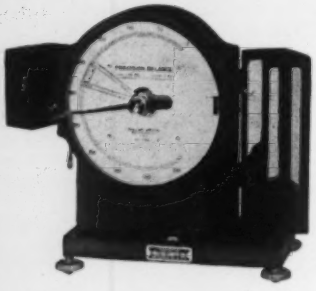
PRECISION BALANCES



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The **Roller-Smith Precision Balance** is universally used for weighing within the range of 3 mg to 150 grams. Everyday applications include the measurement of liquid surface tension, yarn numbering, counting extremely small parts by weight, assaying precious ores, weighing diamonds and specific gravity determinations.

The **Roller-Smith Precision Balance** is the result of careful research and painstaking design to produce a better means for *rapid weighing, quality control* and *uniformity* in the manufacture of your products.

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ROLLER-SMITH

lated from line. Low actuating-circuit energy can cause no appreciable heating, arcing, ionization or chemical change. Probe-to-relay distances can be 3 to 5 times longer, states manufacturer, than in other units now on market.—*R-S Products Corp., 4523 Germantown Ave., Phila. 44, Pa.*

Please mention number 666 when filling out card

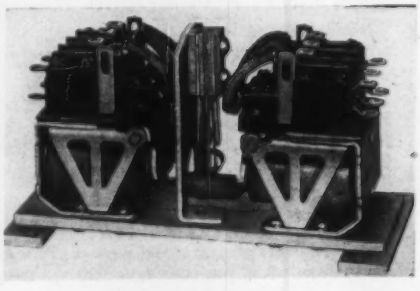
Steam-Jacketed Flowmeter

New "Steam Jacketed Flowrator" is designed for materials having high melting points such as molten sulphur, naphthalene and phosphorus. Remote totalization, recording and control of flow rate is available and flow indication is provided at primary element. Meter indicating extension is furnished with steam heating coils and entire meter body is jacketed for 100-lb. steam gage pressure.—*Fischer & Porter Co., Dept. 5C-K, Hatboro, Pa.*

Please mention number 667 when filling out card

Interlocked Time-delay Relay Combination

New "No. 27-27 Phil-trol Memory Relay" consists of two mechanically interlocked relays and a s-p.-d-t. snap switch operated by interlocking bar. In operation, when one unit is energized,



its armature pulls up mechanical locking bar, which in turn closes snap switch to one position. Switch remains closed until second unit is energized. Among applications operation of servomotors controlling wing flaps, landing gear and propeller feathering devices on aircraft. Supplied for d-c. voltages up to 230, from 1 to 5 pole, single or double-throw combinations, and contact capacity of 10 or 20 amps. Overall dimension: 4⅜" long, 2½" wide, 2⅜" high.—*Phillips Control Corp., 612 N. Michigan Ave., Chicago 11, Ill.*

Please mention number 668 when filling out card

Process Control Timer

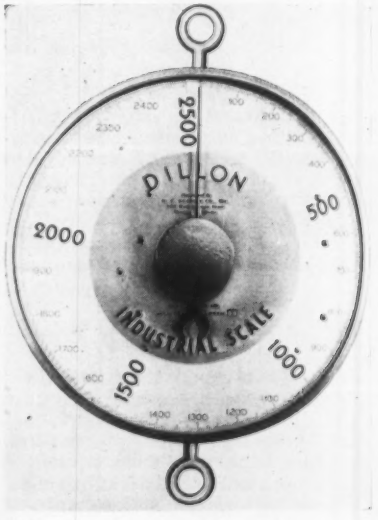
New "Time-Schedule Controller" can be synchronized with air-operated semi-automatic temperature and pressure control systems to make process fully automatic. In use, a signal light flashes on to indicate that process is under way. Timing begins immediately, or, if desired, when temperature

has reached processing point and is maintained for predetermined length of time. Instrument is applicable in canning, rubber, food, beverage, chemical and plastics industries.—*C. J. Taglinbue Corporation (N. J.), 614 Frelingheysen Ave., Newark 5, N. J.*

Please mention number 669 when filling out card

15" Industrial Scale

New "Precision Industrial Scale" is said to embody an entirely new principle of operation, has a 15" dial, is



available in 500-lb. to 10,000-lb. sizes.—*W. C. Dillon & Company, Inc., 5410 W. Harrison St., Chicago 44, Ill.*

Please mention number 670 when filling out card

Vacuum Gage

New vacuum gage is graduated 0 to 30" mercury vacuum in 0.2" increments, and with barometric pressure readings from 29" to 31". Gage may be corrected for changes in barometric pressure by means of external micrometer pointer adjuster. Dial also reads

counterclockwise to prevent confusion with pressure gage, and is designed with the subdivisions in steps for reading to 2/10 of an inch.—*Helicoid Gage Div., American Chain & Cable Co., Inc., Bridgeport 2, Conn.*

Please mention number 671 when filling out card

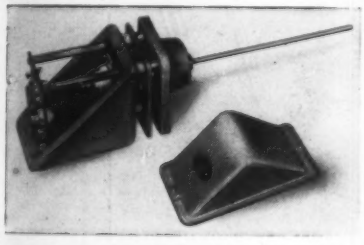
Reversing Superstructure for Diaphragm-motor Valves

New reversing superstructure for use on maker's diaphragm-motor valves permits reversing of valve action by simple substitution for standard superstructure. No need to remove valve body from line, hence saving of many man-hours. Maker states that the same characteristic valve action is maintained when changing from one superstructure to another, including minimum hysteresis, same effective diaphragm area and same spring characteristic. New superstructure is designed to permit relatively high pressure drops with good throttling control. All metal parts except base are bright-finished. Base is 12" in diameter, rust-proofed underneath and bright-red enameled on top. The weight of base, 7½ lbs.; total weight 10½ lbs.—*Leslie Co., 225 Delafield Avenue, Lyndhurst, N. J.*

Please mention number 672 when filling out card

Combustion Safeguard

New "Fireye System FF-6" provides flame failure protection and semi-automatic ignition control for gas-burning equipment as well as for oil-fired equipment having continuous gas-pilot ignition. It comprises "Flame Rod Type 45JQ1" (illustrated) and "Control Type 24QJ5". Flame Rod, mounted near gas pilot on burner plate and projecting into fire chamber, its tip impinging on pilot or main gas flame, is wired to Control which may be located at any convenient point. Supply: 115 and 230 volts, 50/60 cycles; load rating: power contacts 1 hp. plus 125 va. pilot duty; ambient temperature: 32°F. to 125°F. —*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*



Please mention number 673 when filling out card

Toolmakers' Microscope

New "Wilder Toolmakers' Microscope" consists of heavy Meehanite base and post, with microscope bracket

The new Model BL-310 Strain Measuring Equipment with Brush Direct Inking Oscillograph

Now... for the first time

Immediate RECORDS of STRAINS!

● Here's a strain measuring device that produces records immediately for interpretation. The Brush "STRAIN ANALYZER" consists of a Model BL-310 Strain Amplifier and the Brush Direct-Inking Oscillograph. It's completely self-contained, requiring only two external strain gage connections, one dummy gage and one active gage cemented to the piece being tested.

The equipment records either static or dynamic strains (up to 100 cps) and is phase sensitive so that sense as well as magnitude of the measured strains can be read from the record. The "STRAIN ANALYZER" is readily calibrated for individual gages so that the strain can be read from the chart directly in microinches per inch.

When used with Baldwin Southwark SR-4 Gages of 120 ohm resistance, the maximum sensitivity of the unit is 10 microinches per inch strain per chart division pen deflection. An attenuator switch changes the sensitivity in the following steps: 10, 20, 50, 100, 200, 500, 1000 and 2000 microinches per inch per division. While specifically designed for the 120 ohm gage, the equipment can be used for higher resistance gages. It is also applicable for use with any resistance sensitive pickup and can be used to record pressures, temperatures, accelerations, forces, etc., provided the equipment is calibrated in the terms of the particular pickup used. Investigate the "STRAIN ANALYZER."

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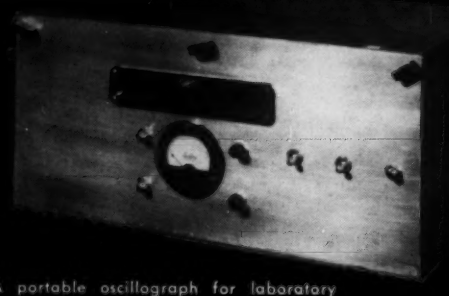
PORTABLE OSCILLOGRAPH



A portable oscillograph for laboratory or field use; this instrument incorporates high standards of accuracy with rugged dependability.

Available with banks of from four to twenty-five hermetrically sealed, pencil-type Century galvanometers in a wide selection of frequencies and sensitivities, this instrument faithfully reproduces on positive recording film bearing simultaneously superimposed timing lines.

Paper widths from 35 mm to 6 inches and a wide range of synchronous motor and tuning fork components are available for operation from 110 volts in the laboratory or for 12-24 volts d.c. truck or aircraft operation. Completely portable daylight developing equipment obtainable if required.

A letter of inquiry regarding the application of this instrument to your needs will receive the prompt attention of our engineers.

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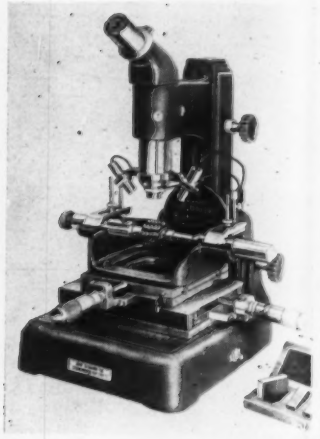
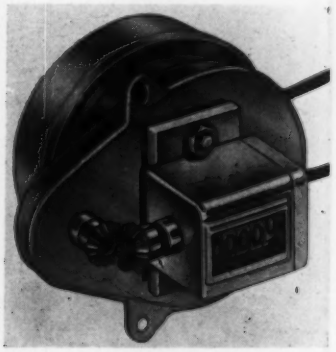


vertically adjustable by spiral pinion. Microscope tube provides magnification of 30×. Eyepiece contains 90° hairline cross and 60° angle for thread measurements. Vertical post may be tilted to helix angle of thread. Work is either laid on compound measuring stage or held in center cradle. Measurements in two directions are by 1" heavy-type micrometer screws that read directly in 0.0005". Incorporates both understage illumination for shadow images and surface illumination.—*George Scherr Co., Inc., 200 Lafayette St., N. Y. 12, N. Y.*

Please mention number 674 when filling out card

Elapsed-time Indicators

Four new models of Elapsed Time Indicators, for indicating total operating time of various pieces of equipment,

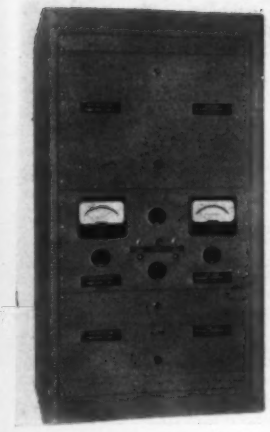


are announced. Models have been revised and expanded to meet requirements of industry. The four new models are in the "No. 5702 series" where brake motors have been added "at prices generally lower than previously charged for units without a brake." This brake action is claimed by manufacturer to stop rotor instantly and prevent coasting after current is turned off.—*The Haydon Mfg. Co., Torrington, Conn.*

Please mention number 675 when filling out card

D-c. Power Supply

"New Type IPS10000 10-kv. Iso-volt D-c. Power Supply" provides source of continuously-variable d-c. voltage from 1000 to 10,000 volts at current drains up to 5 milliamperes. Regulation of 0.1% is obtained and corrects the output voltage, practically instantaneous-



ly, over full line and load variations. Front panel includes coarse and fine voltage controls, two instruments indicating voltage output and load current, main switch, instant operation "on" and "off" push buttons, and fuse. Output connections are made at rear. Operable from 105-130 volts a.c., 60 cycles Power drain approx. 350 watts at full load. Overall dimensions: 22" wide × 41¾" high × 17½" deep. Weight approx. 225 lbs.—*Rowe Engineering Corp., 2422 N. Pulaski Rd., Chicago 39, Ill.*

Please mention number 676 when filling out card

Liquid Level Controller

New "Faratron Model FE Liquid Level Controller" is provided without case, with all parts mounted on back

of plate which becomes both housing and installing panel. Circuit operates without direct electric contact. Measurable power input is 15 microamps. Available for one-level operation—either high or low; or for two-level operation, both high and low.—*Lumenite Electronic Co., 407 South Dearborn St., Chicago 5, Ill.*

Please mention number 677 when filling out card

Gear Checker

New "Conju-gage" for gear inspection embodies a single threaded worm, which can be used to check either spur or helical gears of right or left hand regardless of helix angle. Incorporated in testing instrument of variable center-distance type, master worm section provides quick, economical means of checking composite error in gears. Designed

PROTECTION

by ACCURACY

"Acragage"

For Precision *plus* Economy

For pressures and vacuums . . . with ranges from water inches up to 30,000 P. S. I. . . . there's an ACRAGAGE scientifically designed to give you dependable precision on steam, oil, gas, chemicals, water, or brine. ACRAGAGE comes in a wide variety of sizes — 4½", 6", 8½", or 10", with wall, stem, or true flush mountings. ACRAGAGE cuts down your operating expense . . . protects you against costly errors and inaccuracies.

20% to 30% Longer *Bourdon* Tubes

Bourdon tubes in the ACRAGAGE are 20% to 30% longer than average . . . resulting in the following advantages: less strain per unit length on the spring; increased durability; longer fatigue life; heavier wall thickness for added safety; greater tip-travel — providing sustained accuracies to within one-half of one percent!

Remember ACRAGAGE — a quality product made by skilled craftsmen from materials which meet rigid standards, including Army and Navy specifications.

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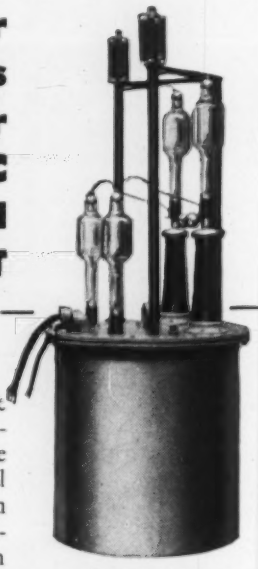
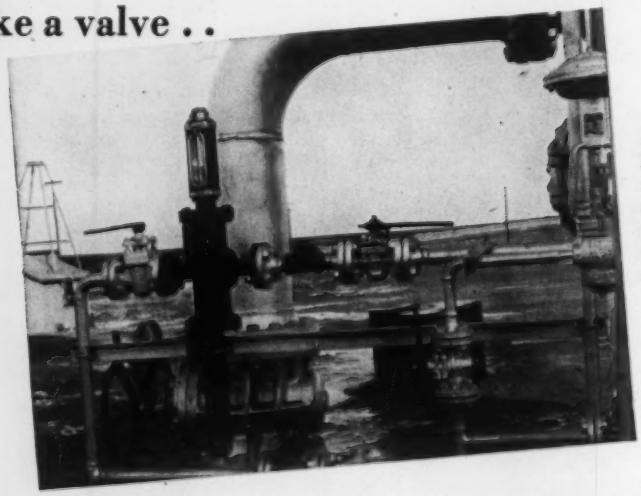


Manufacturers of high-voltage precipitation equipment are invited to take advantage of the extensive experience General Electric has had in the design and application of precipitation transformers for use with electronic or mechanical rectifiers—and with the necessary control for this equipment. Simply send us your voltage and capacity specifications together with any special requirements as to wave shape, need for full or half wave, or for smoothness of output. Our engineers will offer the design best suited to your application. Address inquiries to our nearest office or to *Apparatus Department, General Electric Company, Schenectady 5, N.Y.*

GENERAL ELECTRIC

401-77

This flow meter "takes to" your pipe system like a valve . .



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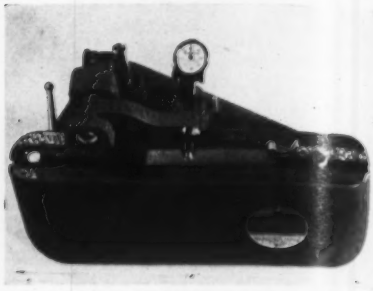
to handle gears ranging in size f[illegible]m the smallest watch pinions to pitch diameters of as much as 8.25". Gear is meshed with rack-like worm section, which is traversed along its axis, and



variations in center distance measured either directly on a gage or by automatic charting device. Separate errors such as profile error, tooth-thickness error, etc., can easily be evaluated from chart.—*Eastman Kodak Co., Rochester 4, N. Y.*

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New "Servicettes" represent a novel idea: combinations of service instruments selected by purchaser. Cases are

7¼" × 9" × 4" and accommodate several instruments, which can be removed for bench operation. In addition, compartments are provided for test leads and tools. Individual instruments may be bought separately, or packed in three different models.—*Radio City Products Co., Inc., 152 W. 25th St., New York 1, N. Y.*

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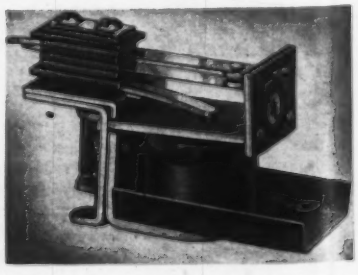
New "Guardian Series 100-U Relay" is for switch applications within rating of contacts. Coils are available for 6v., 12v., 24v., 115v. and 230v., at 60 cycles. Six contact combinations are available. Supplied with ¼" diameter contacts.



Open type switches rated at 12 amperes, 115 volts, 60 cycles, non-inductive.— *Guardian Electric Mfg. Co., Dept. U-100, 1638 W. Walnut Street, Chicago 12, Ill.*

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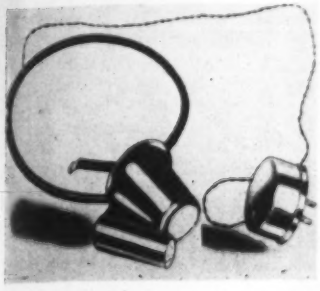
New "L & R Electric-Loupe," has a fully-ground lens with 2" focal length with cool, clear electric light. Equipped



with comfortable, plastic-covered head band and transformer which plugs into any 110 volt outlet. Recommended for use by watchmakers, tool and die makers, engravers, photographers, advertising production men.— *L & R Mfg. Co., 577 Elm St., Arlington, N. J.*

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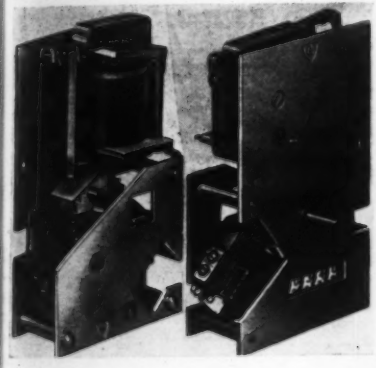
Magnetic Counter

New "Magnet Driven Counter" registers number of musical record selections received from remote points in



centrally wired music station; comprises magnet, counter, counter-actuating assembly, midget contact assembly and lever-cam assembly. When coin is inserted into music machine, switch closes and starts pulsing circuit. Number of pulses transmitted depends on value of the coin. Each pulse actuates the magnet once.—*Guardian Electric Mfg. Co., Dept. M.D.C., 1638 West Walnut Street, Chicago 12, Ill.*

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Cycle Timer for Stokers

New "Thermo-Interruption" model of maker's "Stoker Fire Pilot" is said to be of "revolutionary design" and designed to help coal and stoker industries by allowing use of a wider variety of coals, and to achieve greater economy even with top quality coals. It performs normal functions of maker's "Fire Pilot": knob adjustments permitting 1 to 4 firing periods per hour, each of 1

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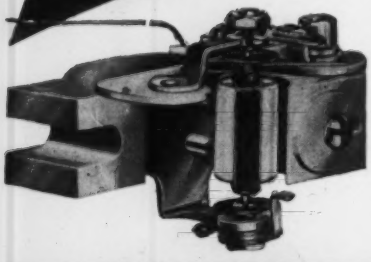

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to 7 minutes' duration; but in addition, it provides similarly-scheduled interruptions during firing cycle itself: it may be set to cause 0- to 7-minute pauses in the firing, 4 times per hour. Interrupting firing cycle, maker claims, greatly improve combustion and eliminates stoker troubles caused by coke trees; also eliminates accumulation of unburned coal in fire box. By enabling burning to keep pace with firing, thermostat "over-ride" is reduced, providing greater heating comfort and increased fuel economy. Maker claims easy installation and simplicity of servicing. Both "Thermo-Interruption" timer unit and relay-transformer unit are complete cartridge assemblies: Either can be replaced without use of tools, without disconnecting or changing wiring, and without removing box from wall. — *Sampsel Time Control, Inc., Spring Valley, Ill.*

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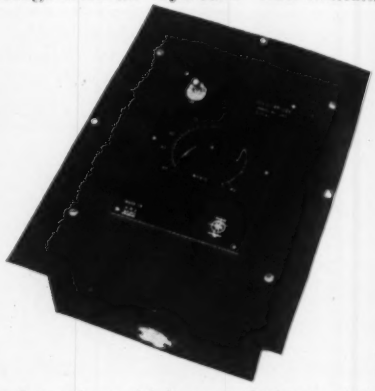
Conductivity-type Controller for Nitric Acid

New "Model RE-29G Solu Bridge" controller is a modified a-c. Wheatstone bridge with an "eye tube" null indicator



and a relay which, on unbalance, delivers up to 2 amperes at line voltage for operation of solenoid valves, warning devices, etc. Control point is front set, range of instrument being 50-80% HNO_3. Temperature compensation is automatic by means of a pre-filled reference conductivity cell. Measuring and reference conductivity cells are of Pyrex construction, with platinum electrodes, and "Type 347" stainless steel 1" NPT fittings for pipe-line installation.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

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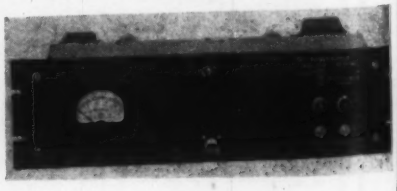
New "Model 710-SR Power Supply" provides d-c. power at high voltage and low current. Applications include operation of photo-multiplier tubes, Geiger-counters, cathode-ray tubes, also where constant, but adjustable, voltage should be supplied. Regulated output voltage is continuously adjustable over



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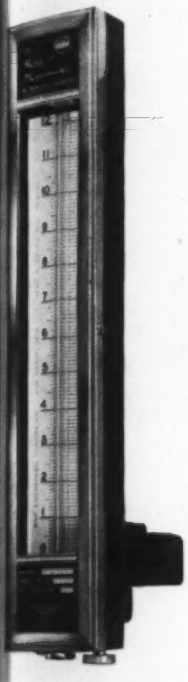

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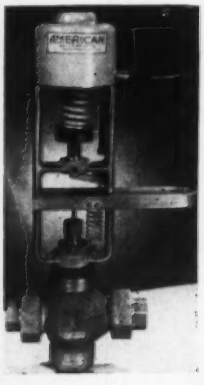

New "American Snap Action Regulator" is for use where positive shut-off is required when critical temperature has been reached. Accuracy of actuation is secured by carefully ground and fitted stainless steel parts. Ease of manually resetting is achieved by simply raising "cocking" lever. Made in three sizes; ½", ¾" and 1" and for temperatures from 20 to 345°F. —*Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn.*

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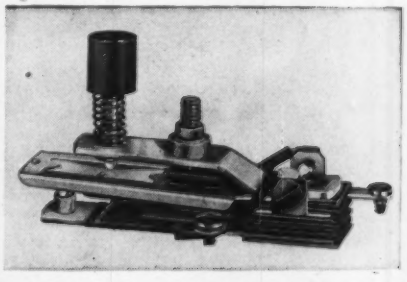

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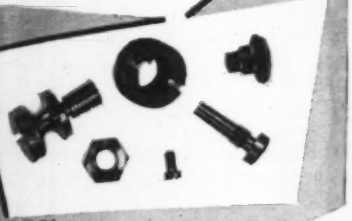

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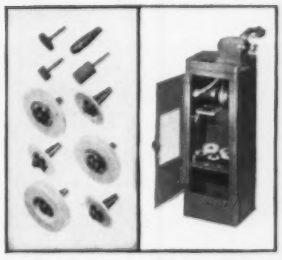

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Analyzing *the* INSTRUMENTATION *of a* CONTINUOUS CHEMICAL PROCESS

By ALLEN L. CHAPLIN, Consulting Chemical Engineer

Introduction

THE problem of instrumenting a continuous chemical process should be approached in a logical orderly manner of analysis to establish a definite working pattern for design and operation of the process. Each processing unit developed by the process engineer has a specific function and has been designed to operate in a given manner with respect to other units of the process. It follows that each instrument applied to the process must likewise have a definite function and must be given a specific allocation with respect to the over-all pattern of control application, lest the instrumentation of the process be inadequate or overdone.

The process engineer has engineered the modern continuous process to a high stage of development and, to a large degree, has transcended the process control engineer in the organization of (1) his own engineering responsibilities and (2) the functional relationship of processing units into a unified design pattern. He enjoins the necessary engineering facilities and services required in process design, and marshals a project through its development and design stages to the complete plant. The process control engineer has not organized his engineering responsibilities so thoroughly and has, for the most part, been forced to follow an assigned program rather than a commanding pattern in the application of process instrumentation.

There are two principal reasons for this condition:

Firstly, the relative functions of the process control engineer with respect to the process engineer and the instrument engineer have not been thoroughly defined and accepted by all industry, and his responsibilities vary depending upon the emphasis placed upon instrumentation in his field. (This is the subject of another article and will not be discussed further here.)

Secondly, the process engineer has reduced his process design problems to a generalized concept based upon *use functions* of individual processing units while the process control engineer has not established a comparable working basis but has concerned himself with the mechanics of control operations as applied to each individual job which confronted him.

*Originally prepared for presentation before First National Instrument Conference, Instrument Society of America, Pittsburgh, Pa., Sept. 1946; presented in 1947 before Eastern New York, Metropolitan New York, and New Jersey Sections of the Instrument Society of America; partly re-written by author and reviewed by others; final revision made in April 1948.

The process engineer has classified the chemical process in terms of unit subdivisions based on the *use function*, or *functional purpose* of each unit process operation, viz., distillation, crystallization, evaporation, absorption, filtration, decantation, etc. Thus, the problem of designing a chemical process resolves itself into the consolidation of appropriate unit process operations.

To achieve the same flexibility in design of process instrumentation, the process control engineer must establish a similar classification of instruments based upon the functional purpose which each instrument serves. With such a pattern of *use function classification*, the problem of instrumenting a chemical process becomes an orderly consolidation of unit operations into a complete control pattern.

Process instruments have been classified by the instrument engineer in terms of functional characteristics and mode of operation principally based upon the type of mechanism and physical principles of operation. For example, temperature instruments have been classified as *indicators*, *alarms*, *recorders*, etc., while flowmeters, pressure instruments and liquid level controllers have been given similar designations. Control equipments have been classified as *proportional*, *floating*, *derivative*, etc., depending on their mode of operation. While this system of classification is necessary to the instrument engineer in evaluating an instrument for a given job, it does not provide the process control engineer the basic criteria for *use function* analysis.

Use Function of Process Instruments

To arrive at a specific classification, we start from the original definition of Instrumentation as (1) *measurement* and (2) *control*.

The principal purpose of instrumentation in the chemical industry is essentially to measure and control physical changes and chemical reactions. Four fundamental thermodynamic conditions determine the course of a chemical reaction and must be measured and regulated to control the reaction. These are (1) Time, (2) Temperature, (3) Pressure and (4) Concentration. Instruments may therefore, be classified accordingly. This classification refers to the four fundamental conditions affecting a reaction and must not be confused with the model terminology established by the instrument engineer.

For example, a humidity instrument may be a temperature-measuring device but it is fundamentally a *concentration* instrument since its purpose is to measure concentration of water vapor in air. *Flow* does not have fundamental distinction in the above classification and consequently a flowmeter becomes either a *temperature* instrument or a *concentration* instrument, depending on its specific use. The use of flowmeters for measuring and controlling temperature or concentration is a matter of convenience. As *temperature* regulators, flowmeters are frequently applied to distillation columns to control steam input. This is necessary as a practical expedient since temperature-measuring instruments are inapplicable. The process has a high time constant and the delayed response of a temperature-measuring instrument might result in unstabilized control. By setting steam input at a fixed value with respect to feed, a given *temperature* is established by virtue of the input Btu's per pound of feed. The control is more stable and the process becomes "locked-in" at the operating point. As *concentration* instruments, flowmeters are of the non-assaying type. They do not measure molecular species directly but become *indirect* concentration instruments by maintaining a fixed flow of reacting material into a reactor which, by virtue of the laws of retention, establishes a given *concentration* of reactants within the processing unit. Ratio-flow control instruments blend gases or liquids at a given rate per minute which results in a non-assayed concentration of blended materials.

Flowmeters are frequently used to control feed to a distillation column and, as such, become *concentration* instruments. The column is essentially a retention vessel and the regulation of feed rate to it with respect to take-off rate, establishes a given concentration of feed per unit time.

Temperature-measuring instruments are also frequently used as non-assaying *concentration* instruments. They are used on distillation columns to regulate reflux or side or top take-off. Again, their use to measure concentration is sound instrument engineering.

The separation of products in a distillation column depends principally upon the number of retention plates and the relative vapor pressures of the constituents. A fixed temperature relationship exists between composition or concentration of given constituents of a plate and, thus, a measurement of temperature establishes a non-assayed measurement of composition.

Temperature-measuring instruments are especially applicable when a large

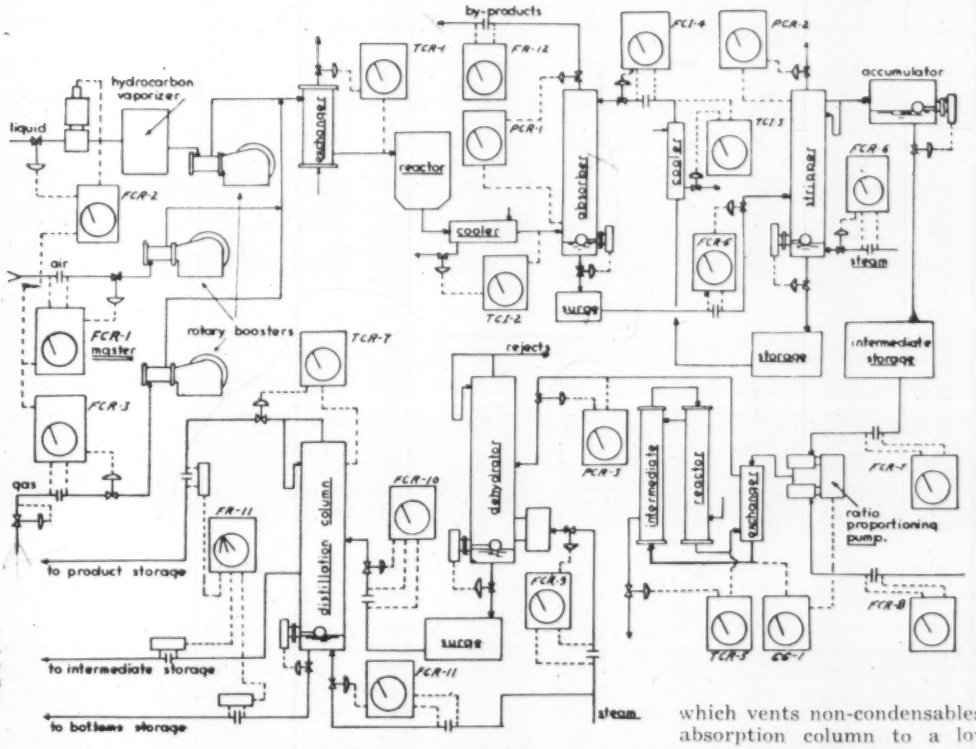

Fig. 1. Application of primary operating controls and primary measuring instruments to typical continuous chemical process.

temperature gradient exists across the plates concerned. If the gradient is low or the vapor pressures of constituents relatively close together, a measurement of temperature is not a good criterion of plate composition and it becomes necessary to use an assaying-type concentration instrument: refractive index, infrared absorption, or other types which have a sufficiently large sensitivity gradient to permit sharp separation and control of take-off.

The application of *concentration* instruments to the chemical process is an involved subject and is treated in another article by the writer. For our immediate analysis we adhere to the *use function* pattern for instrument applications. Each instrument must have a well-defined purpose and the pattern must determine its importance to process operations and its priority of purchase, its cost, its accuracy and sensitivity and its schedule of maintenance. It is unwise to overinstrument a process and, conversely, an instrument should never be overprocessed.

For the purpose of *unit function* derivation, process instruments may be subdivided into at least the following ten major classifications:

A. Primary Operating Controls.
B. Primary Measuring Instruments.
C. Safety Controls.
D. Operating Guide Instruments.
E. Operations Check Instruments.
F. Surge-averaging Controls.
G. Purity-assay Instruments.
H. Quality-control Instruments.
I. Signalling and Communication Instruments.
J. Laboratory Check Standards.

A. Primary Operating Controls

Primary operating controls constitute those equipments which maintain the essential material and energy balances of the process reaction. For example, a typical hypothetical process, as in Fig. 1, burns a gaseous and liquid mixture with air in a reactor to form an intermediate product which is separated from side products in a water absorption column. The water solution of the intermediate passes into a surge vessel while the non-condensables and gaseous side products are taken off as overhead from the absorption column and further processed in a side process for separation of by-products and recovery of gas usable as fuel.

The intermediate product is stripped from the water solvent in a stripping column where it is taken off as top product and stored in a surge vessel for feed equalization to an intermediate reactor. Products of the intermediate tube reactor pass directly to a dehydration column where water is removed as an overhead by-product. The bottom product is separated from high boiling impurities in a final distillation column and goes to bulk storage.

Material and energy balances of this process are maintained by *primary operating control* instruments. The primary reactants are fed to the reactor under pressure by ratio flow controllers FCR-1, FCR-2 and FCR-3. The reaction, once started, is exothermic and temperature of the reactor gases must be regulated by temperature controller TCR-1 which feeds cooling water through the jacketed exchanger. The gaseous products must be further cooled in an interstage cooler by TCI-2 to regulate feed temperature to the absorption column.

Pressure in the reactor is regulated by back pressure controller PCR-1 which vents non-condensables from the absorption column to a low-pressure recovery process.

Temperature of absorption water is regulated by controller TCI-3 before it enters the column and water feed is regulated by FCI-4 to maintain balance with reactor products entering the column.

The stripping column is operated at a lower pressure than the reactor and is regulated by back pressure regulator PCR-2 which bleeds non-condensables to the atmosphere. Feed to the column is regulated by manually-set flow controller FCR-5, while steam input to the indirect heating coils is regulated by FCR-6 to maintain balance with column feed. Reflux is maintained at fixed ratio by fixed weirs.

The intermediate product is ratio-blended with an intermediate reactant by means of an adjustable-ratio variable-speed positive-displacement proportioning pump. Flowmeters FCR-7 and FCR-8 record the flows of reactants to the pump and provide a visual indication of feed ratios.

The normal function of ratio-flow controllers or proportioning pumps is to maintain a constant *volume* ratio irrespective of molecular ratios except for the effects of density on such metering devices. As in most reactors, the efficiency of reaction or yield is contingent upon *molecular* ratios and it is advisable to meter reactants on a basis of measured molecular ratios, especially when purity of either reactant is low and its composition is subject to change. The process described utilizes a refractive index recorder CC-1 as a guide for manual adjustments of feed-pump ratio to maintain fixed molecular composition of feed to the reactor. This instrument may be classified as a purity-assay instrument or

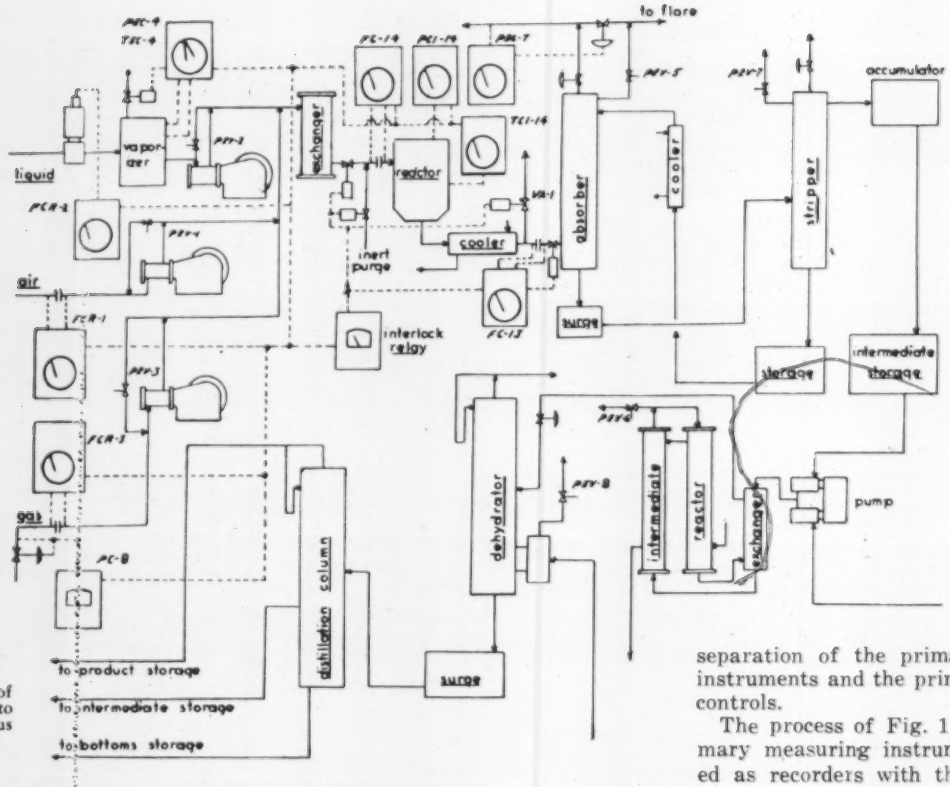

Fig. 2. Application of Safety Controls to typical continuous chemical process.

a primary operating control instrument, depending upon its purpose and mode of application. The border-line distinction depends wholly upon its function in process operations.

The reactor operates at elevated pressure controlled by PCR-3 while heat exchange medium is passed through the reactor shell by TCR-5 to maintain reactor temperature.

The dehydrator is direct-connected to the reactor and its feed rate is effected by PCR-3, while steam input is regulated to a calandria by FCR-9. Reflux is maintained at constant ratio by fixed weirs.

Primary operating controls of the final distillation column consist of feed controller FCR-10, steam flow controller FCR-11 and reflux controller TCR-7. In addition, a side product is taken from the column under control by an instrument described later under *Operations Check Instruments.*

The above-named instruments maintain the essential material and energy balances in the process. For obvious reasons, the primary operating control instruments are of the mechanical functional type and will probably continue as such for as long as process reactions are carried out as a continuous-flow balance of material and energy. Their order of priority is high and while they need not be of the highest order of accuracy, their stability must be high and they may be classified generally as the most important controls in continuous processing. These instruments are usually, though not always, associated with the primary measuring instruments and are given prominence on central instrument panels. Their design must be such that they can be easily operated and readily serviced without loss of time. Many continuous processes are inoperative without these controls and any interruption of the process for instrument repairs invites an unwelcome loss of time, money and materials.

B. Primary Measuring Instruments

The primary measuring instruments may or may not be directly associated with the primary operating controls but their function is to provide records of operations as well as cost and accounting data. They are of the integrating and recording types and in some cases may overlap the functions of operating guide instruments. These instruments are located in the central control room when associated with the operating controls, although in some cases, particularly in applications hazardous as to fire and explosions, they are operated by remote transmitters with receivers located at strategic operating points and sometimes in the Superintendent's office. Accuracy of such instruments is of high order commensurate with requirements of the process. Conditions such as corrosion, explosive hazards, climate, outdoor service, etc., will also determine the type of measuring element and the operating medium. Serviceability is not an important criterion of these instruments and it is not uncommon to find some commercial types divorced entirely from the primary operating controls. In such cases, control equipments with low time constants such as high-speed servos are operated independently of recorders to avoid unnecessary instrument lags. The increased use of fast controls results in more complete separation of the primary measuring instruments and the primary operating controls.

The process of Fig. 1 has most primary measuring instruments associated as recorders with the primary operating controls. Records of inventory, of feeds and balances are provided while additional primary measuring instruments FR-11, and FR-12 provide integrated records of yields of main and secondary products. Flowmeters are used for compiling accounting records of by-product gasses from the absorption column but side processes will not be considered here.

C. Safety Controls

Safety controls constitute an important class of instruments. Chemical processing units are governed by code standards and instruments must be used to prevent overpressures and excessive temperatures. Furthermore, many reactions are hazardous as to explosive limits and inflammability of reaction products or the toxic or vesicant nature of liberated gases. These conditions may, in some cases, require controls of a type which flood the unit or inject an inert gas into the system if dangerous operating limits are reached. The main reactants may be dumped or diverted to other streams to avoid damage. For example nitrating pots in nitroglycerin processing are dumped into a large vat of cold water when the temperature exceeds specified limits. Spinner fires are so frequent in cotton nitration that special instruments are used to start ventilating fans at the first indication of smoke. Flooded plates or overpressures in fractionating columns divert the gas streams to flares and remove inflammable vapors from the area.

Gas analyzers sample air at strategic points for inflammable solvent vapors such as acetone; and detect leaks of toxic vapors in pipe lines. Hydrogenation reactions require sensitive

analyzers such as thermal conductivity recorder-controllers to shut down the process when excessive limits are reached. Boiler controls have associated interlocks which shut off the burners or fuel feed in event of failure of fans or loss of drum water level.

Safety controls are self-contained and automatic. They are, in some cases operated independently of plant power supply and are not affected by climatic conditions or power outages. They are relegated to the task of protecting equipment and avoiding personal injury or loss of life; and quite often signals are operated in conjunction with them for greater personal safety.

Fig. 2 is a duplication of the process given in Fig. 1 but with the above-described primary operating control instruments omitted to clarify the application of *safety controls*.

The composition of gas mixture to the reactor must be maintained near its lower explosive limit and, should this ratio change because of failure of either constituent, limit contacts in FCR-1, FCR-2 or FCR-3 must operate quick-closing valves in the reactant feed lines and open a valve to purge the reactor with an inert gas. At the same time, vent valve VA-1 is opened to vent the reactor to atmosphere. The quick-operating valves are of the locking type requiring manual reset.

Gas velocity over the catalyst gauze of the reactor must be maintained above a minimum limit to avoid flashbacks and flow controller FC-14 will actuate the safety interlock purge in event of subnormal flow. Gauze temperature must not exceed a specified limit to avoid flash burn-outs; and excess pressures in the reactor must be avoided. These conditions are avoided by temperature controller TCI-14 and pressure controller PCI-14 which operate the interlock system.

In addition to the safety control instruments, the reactor is also provided with safety explosion heads.

One reactant gas is purchased as a by-product from a neighboring plant and is subject to fluctuating pressure particularly if safety controls in their plant operate to relieve an emergency. A pressure regulator is installed in the supply line as a *primary operating control*, ahead of the booster compressor, but this is supplemented by a low-pressure *safety control* instrument PC-8 which trips the purge interlock system in event of low supply pressure.

The booster compressors on all three feed lines are equipped with pressure relief valves PEV-1, PEV-2 and PEV-3 connected from the discharge to suction sides to free the compressors in event of overloading.

Description of the liquid feed system beyond the booster compressor has been omitted but suffice it to say that FCR-2 (Fig. 1) meters the liquid to a vaporizer and is compensated for specific gravity variations because of the necessity for a fixed weight ratio between this constituent and air. The vaporizer is equipped with its complement of instruments for temperature control, etc., and is protected from over-pressures by pressure-relief controller PEC-4 which exhausts to atmosphere and simultaneously actuates the purge interlock system at the reactor.

Reaction conditions at the reactor are somewhat hazardous and its products are toxic. Should the operators find it necessary to egress, they may operate any or all *safety controls* from an outdoor pilot station and ventilate the operating room by means of remotely-operated ventilating fans.

Relief of pressure at the reactor may cause a backflow from the absorber which is avoided by anti-reverse flow control FC-13. This is an automatic trip instrument which requires manual reset.

The absorber column is protected against over-pressure by pressure-relief valve PEV-5 and also expendable explosion disks. The intermediate reactor is equipped with an over-pressure relief valve PEV-6 which diverts products to a catch basin.

Protection must be provided at the absorber against excessive back-pressure in the by-product take-off line to the side process. If this back-pressure becomes too high, a pressure exhaust controller PEC-7, diverts the gases to a flare.

All safety controls operate in the "safe" direction in event of power failures.

D. Operating Guide Instruments

Operating guide instruments serve to indicate conditions of process operation. They may or may not be included with the primary measuring instrument but their function is to provide check data on all secondary factors which reveal balance conditions affecting process operations. Such instruments may be centrally panel-mounted or they may be installed locally on the equipment if cost of centralized installation is high and their importance secondary. Usually they indicate changes in operating conditions before operating instruments have time to function.

For example, dephlegmator outlet water temperatures, heat exchanger temperature drop or agitator drive power requirements are conditions which do not affect directly the process reaction but serve as guides as to the behavior of the reaction and also the equipment. Industrial thermometers on the coolant and discharge lines of a heat exchanger provide information for heat balance calculations while pressure gages across a packed column will indicate fouling of the packing. Temperature recorders on autoclaves or high-pressure synthesis units indicate the location of a "hot zone" or zone of reaction and serve as guides to the behavior of the reaction; continuous records of temperature of catalyst beds reveals the catalyst activity; pH recorders indicate the need for regeneration of filter beds or absorption beds and the thoroughness of backwashing. Thermocouples peened into tube sheets of boilers or heat exchangers serve as temperature guides against corrosion of the equipment. Maintaining heating surfaces at temperatures above the condensation temperature prevents attack of the metal by acidic gases.

Conductivity recorders serve, in many cases, as guides to sewer losses and also water purity. Level recorders (not averaging type) are used as indicators of storage tank contents and electrical contacting alarms warn of sludge accumulations in processing units. Excessive bearing temperatures, extreme furnace-roof temperatures and leaky condenser tubes which allow contamination of product are conditions which must be guarded against with *operating guide instruments*.

It is often desirable to obtain records for time-motion studies or for power consumption studies, peak load requirements, power outages, supply disturbances and equipment "downs" or failures. Operating records are obtained for such purposes on portable instruments which can be installed temporarily or permanently as preferred.

Operating Guide Instruments need not, in all cases, be of a high accuracy type. Some applications require high sensitivity while others permit equipment design on a cost competitive basis. Fig. 3 is a duplication of Figs. 1 and 2 but omits all previously described instruments to clarify the application of operating guide instruments.

Indicating pressure gages PI-1 and PI-2 are installed in the gas supply lines to the compressors while PI-3, PI-4 and PI-5 are installed on the discharge side to give the operator a visual indication of operating conditions. Thermometers TI-1, TI-2 and TI-3 are installed in the cooling water lines from the compressors to guide the operator in regulating flow of cooling water to the jackets. Thermometers TI-4 and TI-5 provide visual temperature indication of temperature of gases entering the compressors.

The gas mixture must enter the reactor at a temperature not exceeding specified limits. A self-operating temperature controller controls cooling water to an interstage cooler while temperature indicator TI-6 provides visual indication of gas temperatures to the operator. Pressure indicator PI-6 is a dial gage mounted on the central instrument panel and guides the operator during emergencies and start-ups in bringing the reactor up to pressure.

Moisture content of the reactor feed gases affects the weight-ratio of air and liquid reactant. A dew-point recorder TR-7 provides a continuous record of moisture content of feed gases and guides the operator in making appropriate adjustments on ratio-flow controls FCR-1 and FCR-2 (Fig. 1). The air-flow controller is compensated for temperature and barometric pressure so that automatic compensation is made for air density changes.

Composition of the purchased buffer gas is subject to slight changes of one constituent. This is not serious if the concentration does not exceed a specified limit except for inaccuracies of flow measurements by virtue of density changes of the gas. A thermal conductivity type continuous gas analyzer, CI-1, analyzes the gas stream and provides a reference record as a guide to the operator in resetting ratio adjustments of the primary ratio-flow controllers.

Temperature indicators are installed at the various coolers and heat exchangers in the system; and pressure gages are likewise installed at various points for well-known reasons; but for brevity's sake will not be described.

The absorption column contains packing and is subject to fouling. A pressure-difference recorder PR-7 provides a continuous record of pressure drop across the column and reveals accumulative plugging. When the pressure difference exceeds a fixed maximum the column is steamed.

The operating engineer wished to maintain records of heat balances within the absorber to plot the efficiency of absorption. Thermometers and temperature recorders (not shown) are installed in the gas and water inlet and outlet lines for this purpose.

An indication of level in the intermediate surge chamber by LLI-1 guides the operator in making adjustments of the set point of FCR-5 (Fig. 1) to establish equality of processing rates within the stripper and absorber. In this particular process it was preferred to operate the stripper independently of the absorber. Had the two units been cascaded, a *surge averaging control* would have replaced LLI-1 and would have operated the set point of FCR-5 (Fig. 1) automatically.

A pressure difference recorder PR-8 is connected across the stripping column to indicate fouling of the plates. Temperature indicator TI-7 is installed at a few plates above the feed plate since a large temperature gradient exists there and provides the operator with a guide as to operation of the column.

The surge tank following the stripper must take up the difference in throughput rates of the stripper and the intermediate reactor. A liquid level indicator LLI-2 guides the operator in making equalizing adjustments.

Operating guide instruments on the intermediate reactor consist of pressure gages and thermometers to indicate conditions of operation of this unit. The dehydrator and distillation column likewise have pressure gages and thermometers for "on-the-spot" checks of operating conditions. Pumps are equipped with discharge pressure gages; and many other similar applications, well known to the control engineers, are omitted here for simplicity. Level gages on the product receivers serve the obvious purpose of indicating production margins.

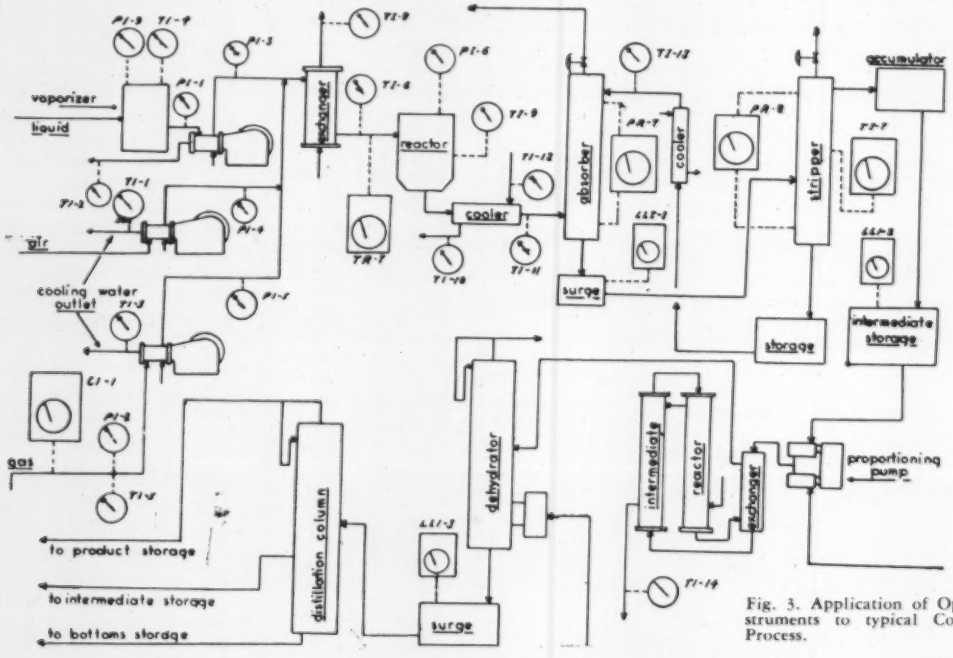

Fig. 3. Application of Operations Guide Instruments to typical Continuous Chemical Process.

E. Operations Check Instruments.

Operations check instruments, to the continuous process, are so important that they must be given equal priority with the *primary operating controls*. The continuous process is a more complicated system than the batch process and, therefore, is highly vulnerable to internal breakdown. Just as large political organizations or business corporations which expand in organizational complexity also increase their own internal friction and must set up special agents to maintain order, so must the continuous process be provided with special guards. Just as any complicated mechanism is more difficult of adjustment than a simple one, so is the continuous process. *Operations check instruments*, therefore, are the *secret police* of the continuous process. Their chief function is to detect the presence of impurities and products of side reactions which set up disturbances in the system. The following analysis will show the need for these instruments:

Fig. 4 is a block flow diagram of a continuous process. The main forward flow of reactants is shown by heavy lines while all recycle loops are less bold. The reaction efficiency of continuous processing units is low compared to batch, and the deficiency is made up, in part, by recycling the unreacted components of the unit for reprocessing after the product of reaction has been separated. The separation operation does not, in all cases remove the analog or side products and the effect on the system, of returning

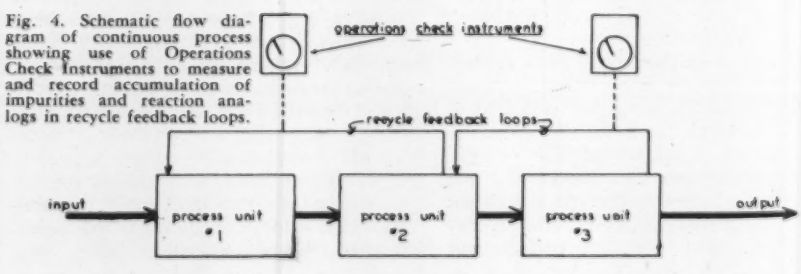

Fig. 4. Schematic flow diagram of continuous process showing use of Operations Check Instruments to measure and record accumulation of impurities and reaction analogs in recycle feedback loops.

these products through the feedback loops to the input stages, is to set up degeneration in the system. They drive the reaction to the left and decrease yields and efficiency.

So far as the process is concerned, these analog products are impurities

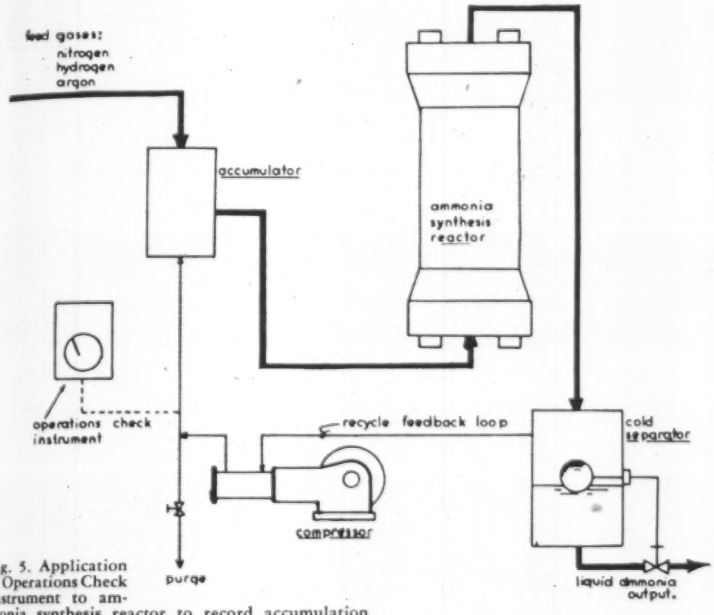

Fig. 5. Application of Operations Check Instrument to ammonia synthesis reactor to record accumulation of argon in recycle feedback loop.

and although their presence is very undesirable and sometimes plaguing from an operations point of view, they serve a useful purpose as indicators of system balance. A continuous direct measurement of these impurities, or indirect measurement of conditions which they establish, is one of the best means of ascertaining whether the processing unit is "on the beam." Instruments used for this service are usually of the assaying concentration type, although in some cases an extremely sensitive measurement of temperature showing a change of 0.1°C. in 100°C. has been used. In the absence of suitable continuous instruments for this service, it is customary to take periodic "grab samples" for laboratory analysis.

The following is a typical example of the phenomena described above. Fig. 5 is a block flow diagram of an ammonia synthesis unit. Nitrogen and hydrogen gases are reacted on a catalyst at elevated temperature and pressure to form ammonia. The product is separated from unreacted gases by "freezing out" in a cold separator and the unreacted gases are returned to the input stages for reprocessing. The recycle loop becomes circulating and collects argon which is neither reactive with feed gases nor completely removed as a soluble component of the liquefied product. The effect of this build-up of argon is to drive the catalyst reaction to the left and decrease ammonia yield by decreasing the effective partial pressure of reaction gases. It is highly desirable, therefore, to obtain a continuous-run record of argon concentration in the feedback loop. Instruments of the thermal conductivity type are generally used for this specific application.

Other examples of the *operations check instruments* follow.

Carbon monoxide is removed from ammonia synthesis gases by reaction with copper formate solution which becomes reduced to a lower valence state. Instruments of the visible-light photometer type are used as *operations check instruments* for the continuous analysis of this solution for recycling impurity, carbon monoxide.

Boiler feed water contains mineral salts which accumulate in the mud drum and upset heat transfer balances. The mud drum behaves as a recycle loop and collects the salts as an impurity. Electrical conductivity equipment is used as *operations check instruments* to measure the concentration of these salts and control boiler blow-down.

Copper-winning reactions carried out on the continuous basis with the electrolyte circulated continuously through the cells and into regeneration stages, are affected by accumulations of nickel sulphate in the recycling system. This salt behaves as an impurity and upsets electro-winning reactions. It must be checked by periodic laboratory analysis of the recycle electrolyte using polarograph equipment as *operations check instruments*.

In the operation of a binary still or fractionating column with top feed, impurities from recycle loops in the preceding system may have a boiling point below the bottoms but above the top product. They accumulate in a center section of the still and result in flooding of the column. To avoid this, the center plate where build-up occurs is tapped and the impurity bled off as a side product by continuous specific gravity, or perhaps refractive index type, *operations check instruments*, as shown in Fig. 6.

Frequently conditions have been encountered wherein one reactant short-circuited a continuous reactor and accumulated in the decanter of a stripper column with a resultant upset in column operation. Relocating the feed point and installing an *operations check instrument* to control reflux by measurement of recycle impurities, as shown in Fig. 7, cleared the trouble.

It is common practice in closed distillation systems to return the bottoms

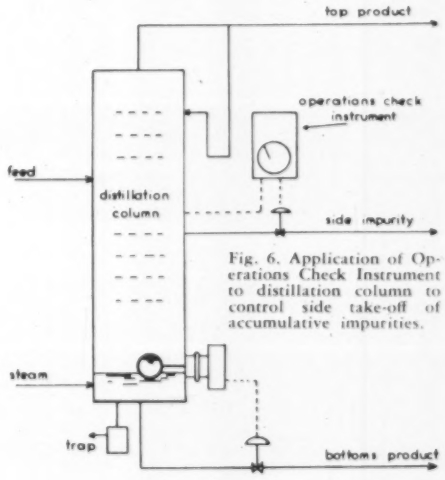

Fig. 6. Application of Operations Check Instrument to distillation column to control side take-off of accumulative impurities.

product to a scrubbing column where a non-condensable constituent is separated from an immiscible phase. The miscible constituent is removed from the solvent by stripping and the solvent returned for further scrubbing. The recycle loop formed by this closed solvent extraction system collects impurities which reverse the extraction reactions in the scrubber.

Fig. 8 illustrates a general application of *operations check instruments* in this manner; and Fig. 9 is a specific application to the process described in Fig. 1. The "bottoms" water from the stripper recycles through the absorber and collects a soluble impurity in the feed back loop. The system must be purged constantly and fresh make-up water added to control impurities concentration. Gravity controller GCR-1 operates the purge valve while fresh make-up is added through a level control valve. Refractometer CC-2 (Fig. 9), controls the take-off of a side *impurity product* from the final distillation column.

Operations check instruments must be sensitive detectors. It is important to maintain reaction analog products and impurities as low as possible—in some cases not above a few parts per million, and it is necessary to detect them at concentrations below the threshold limit. The importance of impurities measurements and operations check instruments is not fully appreciated by many process control engineers. It is a relatively unimportant factor in batch or intermittent operations, but the continuous process is exceptionably vulnerable to impurities accumulations, and many unguided attempts to instru-

ment a continuous process have failed because no consideration was given to the reaction analogs which reverse equilibrium ratios and can stop the process entirely if permitted to build up to sufficient concentrations. As one plant manager put it, "It's not what I know is there, but what's not supposed to be there, that causes my trouble."

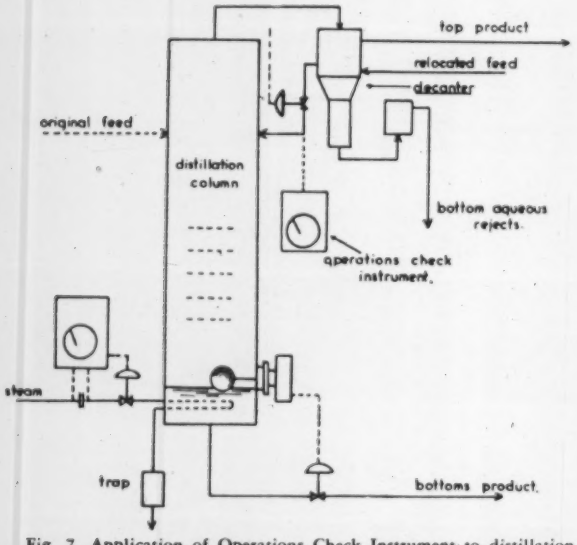

Fig. 7. Application of Operations Check Instrument to distillation column to measure accumulation of water-soluble impurities in reflux loop.

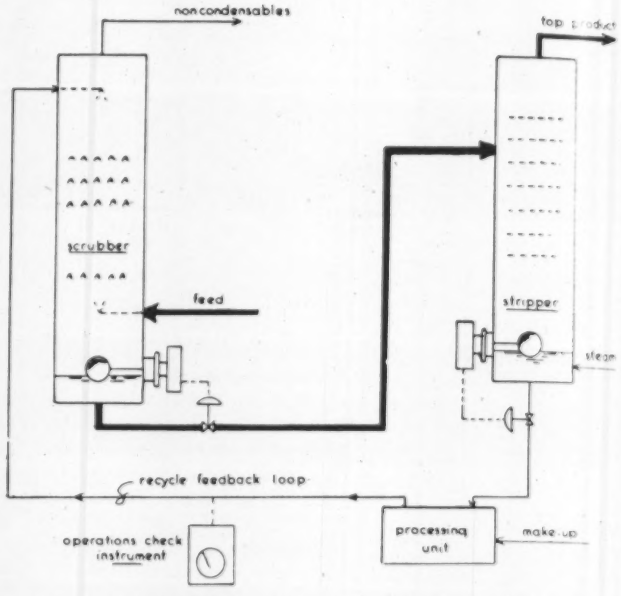

Fig. 8. Application of Operations Check Instrument to record accumulation of soluble impurities in closed scrubber system.

F. Surge Averaging Controls.

When an intermediate stage of a continuous process is diverted, the preceding one and following stages must continue without interruption lest the process be shut down entirely. This is made possible with storage capacity at intermediate points. Unit process operations of an interconnected process usually have different control-rate characteristics with unequal time constants, thus resulting in different rate changes of output following a load change. The practical operation of a cascaded system is made possible by interconnecting each stage with surge capacity controlled by an averaging type level controller. The function of this controller is to translate the rate-change of one stage to the following stage. It makes possible series operation of two stages at different rate changes for a period of time sufficient to transfer a load change throughout the system without sharp upsets.

It may not be necessary in all cases to use surge capacity and averaging controls except for the provision of removing one unit from stream for intermittent conditioning. So far as the control balance is concerned, surge-averaging controls may not be required between interconnecting units when their respective residence factors or control time constants are equal. This is especially true when the residence factors are small as illustrated in Fig. 10-A; and it may apply in some cases to units of large but equal time constants as illustrated in Fig. 10-B.

If a unit of high residence feeds a succeeding stage of very low control time constant, as illustrated in Fig. 10-C, the surge-averaging control may be omitted in some cases because the residence of the large stages serves as surge for the following stage. The reverse is not always true; and an averaging controller is usually required when an interstage unit having low time constants feeds one of much greater time constant as illustrated in Fig. 10-D.

The evidence of this relationship is important in the concept of designing a process with inherent self-regulation. Notwithstanding the many factors involved in unit design which favor self-regulation, it is apparent that a cascaded system of residences arranged in progressively decreasing magnitudes of time constants, as illustrated in Fig. 10-E, is inherently self-regulating and can be operated with simpler instrumentation than a system not having this feature.

The instrument engineer has made available a technique of instrumentation which minimizes the necessity for surge-averaging controls and also makes possible, in some cases, a reduction in volume inventory of processing equipment. The *cascaded control system* can be applied to series or branch-arranged processing units and can be so adjusted to transfer load changes of a preceding stage to a succeeding one without the necessity for large volume surge. It is the writer's opinion that the principle of cascade control operation is the most outstanding single contribution in instrument engineering and it will probably play a dominant role in our common efforts of the future to increase production per dollar investment in plant properties and equipment.

G. Purity Assay Instruments.

Purity assay instruments, as the name implies, are used to analyze for purity the intermediate products and end products of reaction. These instruments are used in the laboratory as supplements to gravimetric or volumetric procedures, or, where possible, they are applied as continuous recording equipments for plant application. They are usually of the assaying-*concentration* type, i.e., titrimeters, spectrophotometers, photometers, densitometers, conductance meters, etc.

In many cases temperature-measuring instruments are used as *purity assay* instruments. A resistance thermometer type instrument has been developed having an accuracy and sensitivity of $\pm 0.01°C.$ at $\pm 0.01°C.$ over a continuous range of $-190°C.$ to $600°C.$ Temperature-measuring instruments are not usually regarded as purity assay types but since melting-point depressions of solids are criteria of purity, especially in the high-purity ranges above 98%, and since this instrument was developed for purity determinations, its application as a process *purity assay* instrument is suggested.

Further evidence of application of continuous analysis instruments is given in the use of electrical conductance instruments in the manufacture of sulphuric acid to provide continuous records of oleum strength or product acid strength. Thermal conductivity recorders give continuous analysis records of product hydrogen purity in the manufacture of this gas by any of the various methods used. Ultraviolet spectrophotometers may be applied to distillation columns to measure and record purity of benzene or butadiene. Chlorine gas from electrolytic cells may be analyzed for purity by special thermal conductivity equipment or by electrical conductance equipment using standard alkali as an absorbent.

In the manufacture of oxygen, thermal conductivity instruments are used

to analyze purity indirectly by measuring hydrogen-loss after combustion of a metered sample. Other instruments, operating on principles of paramagnetism or temperature rise caused by burning the oxygen with a reference fuel, are also used for the same purpose.

Organic products, in many cases are analyzed by refractive index measurements; and x-ray photometers have been applied to assay analysis or blending of high-atomic-number elements, i.e., tetraethyl lead in gasoline, sulphur in oil or ash in coal. Some resins and certain organic materials which are used as the dielectric of capacitors are analyzed for purity by dielectric constant instruments. Specific gravity measurement is widely used as a purity measurement in alcohol distillations.

The sensitivity and accuracy requirements of *purity assay* instruments is of high order and they should be sufficiently stable in calibration to require only periodic checking, especially when applied to continuous stream analysis. At present these instruments are used as supplements to laboratory control equipment, and their priority is not high compared to *primary operating controls.*

The continuous process illustrated in Fig. 9 employs a thermal conductivity recorder CR-2 to analyze and record continuously the blended gases entering the reactor. An instrument is preferred to analyze and record continuously the concentration of product leaving the reactor but, because of unfavorable conditions of application, this analysis is carried out on laboratory grab samples taken at periodic intervals.

The refractive index controller CC-1, Fig. 1, may be classified as a purity assay instrument since it analyzes the blended reactants for proper molecular ratios and is used as a guide in resetting the primary operating controls. Analysis of the intermediate reactor product is only required on an intermittent schedule and this operation is confined to periodic laboratory analysis rather than continuous stream analysis.

The final product is analyzed for purity by continuous specific gravity recorder CR-3.

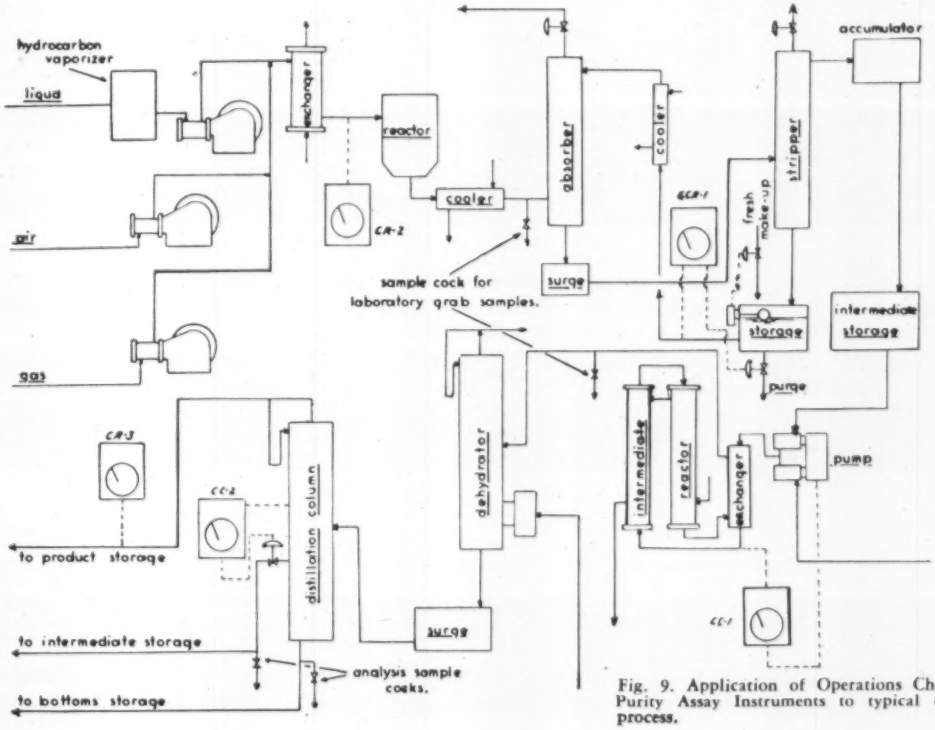

Fig. 9. Application of Operations Check Instruments and Purity Assay Instruments to typical continuous chemical process.

FIG-10A. CASCADED PROCESS UNITS HAVING LOW TIME CONSTANTS. SURGE NOT ALWAYS REQUIRED.

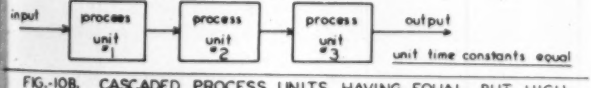

FIG.-10B. CASCADED PROCESS UNITS HAVING EQUAL BUT HIGH TIME CONSTANTS.

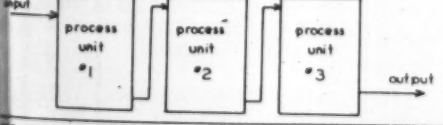

FIG.-10C. CASCADED PROCESS UNITS OF HIGH TIME CONSTANT FEEDING UNIT OF LOW TIME CONSTANT. SURGE NOT ALWAYS REQUIRED.

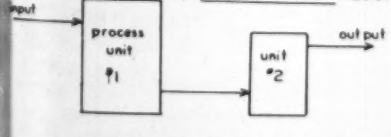

Fig. 10. A, B & C. Showing schematic relationship of process unit time constants and surge averaging controls.

FIG-10D. CASCADED PROCESS WITH UNIT OF LOW TIME CONSTANT FEEDING UNIT OF HIGH TIME CONSTANT-SURGE USUALLY REQUIRED.

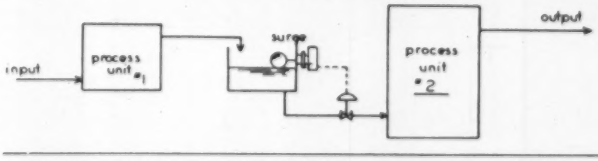

FIG-10E. CASCADED PROCESS UNITS HAVING PROGRESSIVELY DECREASING TIME CONSTANTS. SURGE NOT ALWAYS REQUIRED. PROCESS HAS INHERENT SELF-REGULATION.

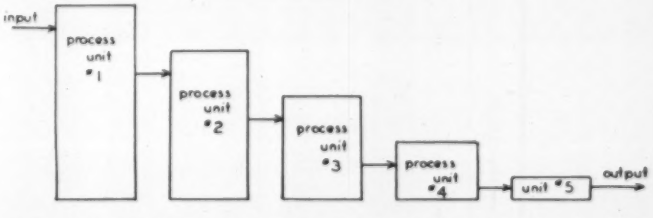

Fig. 10. D & H schematic illustration of relationship between process time constant and surge capacity.

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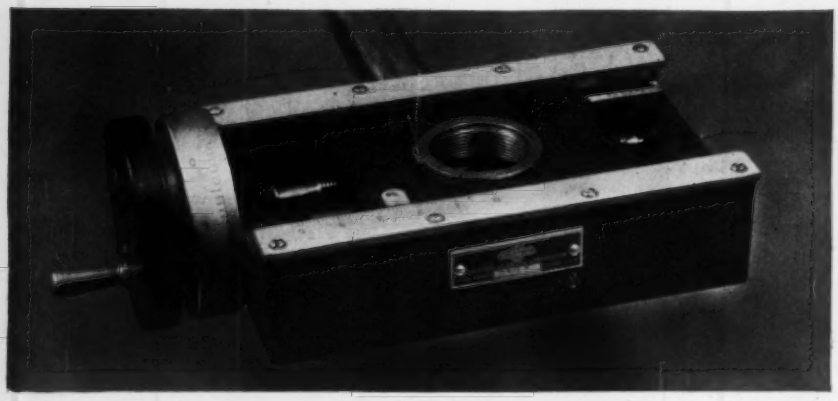

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H. QUALITY-CONTROL INSTRUMENTS.

Quality-control instruments have a different function from that of purity-assay instruments and do not apply to operations of the chemical manufacturing or petroleum refining industries. These instruments apply only to the products of the chemical processing industries, i.e., paper, textile, rubber, plastics, piece goods manufacture, etc. The first two industries require only an analysis of the chemical purity of product, whereas the processing industries require additional physical tests of product and also a statistical average of quality over a lapsed period as well as a projected period of time.

The rubber and plastic-goods industries, for example, may run finished sheet through a high-voltage dielectric strength testing machine to locate pinholes, or the product may be run through a continuous-weighing device to measure uniformity of thickness of running stock. Continuously-dyed fabrics are checked by photoelectric color-matching instruments and a statistical record made of percentage off-register production. In some cases, the instrument may also be applied to produce a record of projected probabilities of off-register production of materials yet unprocessed, by differentiating the statistical behavior of accumulated off-register production. The importance of such a measurement is immediately evident to the control engineer since by virtue of the Gauss relationship of standard deviation, he can predict off-register production and take corrective steps to prevent its occurrence. We have heard much discussion about mythical anticipatory cascaded process controls but the only true anticipating mechanism is the quality control instrument which derives its measurement as a statistical differentiation of the cumulative error.

Paper from a Fourdrinier machine is quality-controlled in a number of ways. It is checked for weight by continuous scales and is calipered for thickness by continuous gages. Color is, in some cases, checked continuously by photoelectric equipment and analyzed periodically in the laboratory with a spectrophotometer of the Hardy type. Recent developments in the use of an oscillating prism and multiplier-type electron tubes in conjunction with an oscillograph, give promise of an instrument of the spectrophotometer type for continuous analysis of a running sheet of paper.

Automobile tires are examined for flaws in vulcanization by means of ultrasonic equipment. Coatings of insulating materials on metallic bases are checked for uniformity of thickness by magnetometers and checked for pinholes with electrical conductance testers. Molded materials must be checked for uniformity of texture and density while many extruded plastics and laminates require surface hardness evaluations.

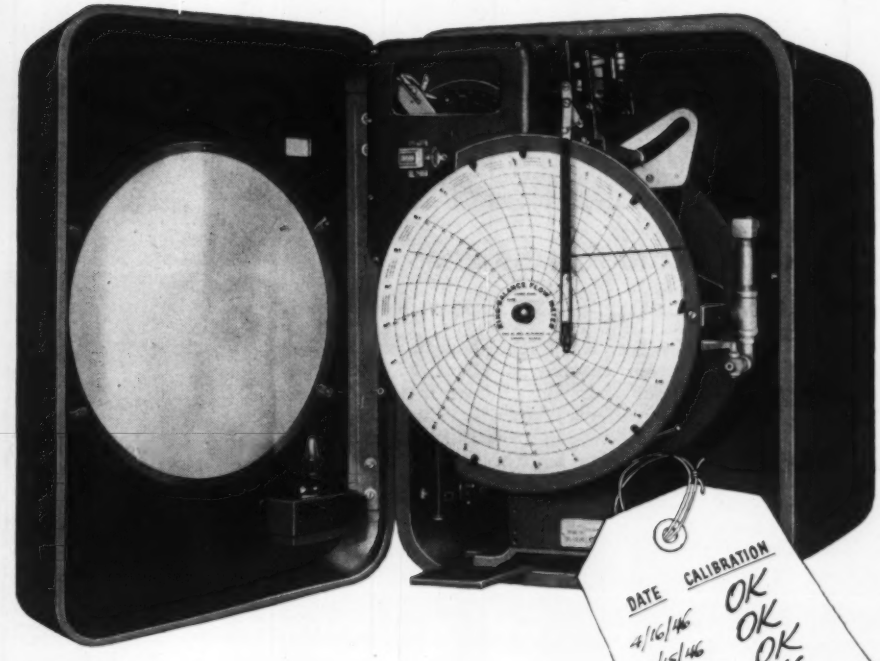
It is not possible to list in this article all quality-control instruments for all chemical processing industries. It may be said, however, that this class of instruments bridges the gap of instrumentation in all industries. Their purpose in the chemical industries parallels those of other industries as for example gaging of mica thickness and density in the manufacture of electrical equipment, and production-line gaging of mechanical parts for tolerance of size and smoothness. In the casting of metals, these instruments make their appearance as high-voltage x-ray equipment or ultrasonic instruments or magnetometers for the location and identification of segregations or cracks and casting flaws.

Quality-control instruments are frequently located at the point of application and usually are connected with remote indicators installed in the superintendent's office. They are more generally used as integrating counters or automatic reject devices and alarm signals rather than continuous recording equipments.

(To be concluded)

CHESTER H. GIBBONS

The field of instrumentation lost an outstanding authority in the death on April 1 of Chester H. Gibbons, Application Engineer, Baldwin Locomotive Works. He is remembered by *Instruments* readers as the author of the serial—later issued in book form—on "Materials Testing Machines."



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INSTRUMENTS ON THE MARCH

Microtime Instrumentation Featured at Navy's New Michelson Laboratory

TERMINAL ISLAND, Calif.—Navy scientists have developed a novel all-electric camera capable of accurately "magnifying" time four million times. This Zarem camera, invented by Dr. A. M. Zarem, heads the list of a series of ingenious precision time measuring instruments and devices used in photographic microtime technique, it was announced May 8 at the Navy's dedication of the new Michelson Laboratory at the Naval Ordnance Test Station, Inyokern, Calif, in the heart of the Mojave Desert.

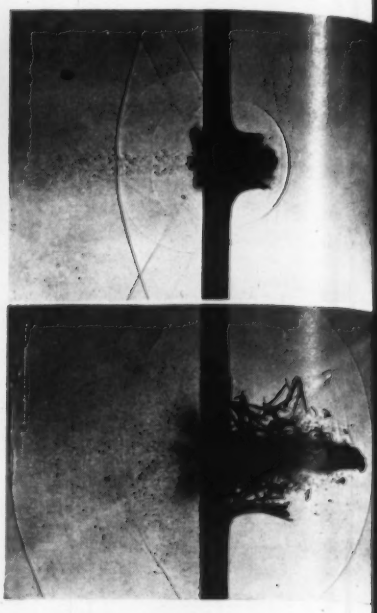
These instruments open a new field of scientific analysis by means of synchronized microtime photography. The shutter of the Zarem camera has been operated so fast that light travels only 10 feet during the time of one exposure. Used primarily for the study of rapidly-changing phenomena which heretofore science has been unable to observe and record accurately, the Zarem camera is about 25,000 times faster than the fastest motion-picture camera commercially available. Its rate is one hundred million frames per second. Its shutter is not mechanical but is a Kerr cell, a glass tube filled with nitrobenzene in which a pair of electrodes is immersed. This cell is placed between two polaroids crossed so that no light can be transmitted. When high voltage is applied to the electrodes, the state of the polarization of the polarized light is immediately altered, allowing the image of the subject being photographed to pass through to the film. The primary applications of this technique are to phenomena of ultra-short duration. The entire history of an event under observation may take place in one or a few millionths of a second.

Other types of ultra-high-speed cameras developed by the Navy include one with seventy-six lenses which is able to take pictures at the rate of 400,000 frames per second. The lenses are arranged in an arc around an octagonal mirror which rotates at 30,000 rpm. Light from the subject is reflected from the rotating mirror through the arc of lenses to a stationary strip of ordinary 35-mm. film. Known as the RC-4, this camera was developed by Dr. I. S. Bowen for the Navy program.

Similar to the RC-4 camera is the RC-3 camera, which uses the principle of the rotating mirror but contains no shutter. Although it is not a true m tion-picture camera, but gives only smear type of photographic record, has been most valuable in certain stu ies of Naval Ordnance.

The rotating-mirror principle is use in still another type of high-spe photographic analysis. Time-resolv spectrograms may now be obtained brief phenomena such as electr sparks. Typical electric sparks la from one to twenty millionths of second but with this method scientis are able to tell at what time duri the brief history of the spark vario parts of the spectrum are forme thereby obtaining a record of t stages of metallic composition, tempe ature, pressure, etc.

Other microtime instruments are t shadowgraph and shock channel whi photographically record ordinarily i



FASTER, FASTER!—Two frames of a motion picture of a .22-caliber bullet shot through plywood, taken by the Navy's improved Schlieren method. *(Official U. S. Navy photograph.)*

HISTORIC INSTRUMENT. — Dr. F. E. Roach, Navy scientist, examines the original Michelson Interferometer exhibited at the dedication of the new laboratory named in honor of Dr. Albert A. Michelson. *(Official U. S. Navy photograph.)*

ORDINARY ELECTRODES, UNIQUE SPECTROGRAPH.—Dr. W. M. Cady, Navy physicist, is shown adjusting electrodes—a job almost every *Instruments* subscriber has done at some time or other—just a routine chore to those who are spectroscopists. The instrument, however, is unique: it is the Navy's new Time-resolved Spectrograph which accurately records the *changes* in the spectrum of a spark or other flash phenomenon having a total duration of only a few millionths of a second. *(Official U. S. Navy photograph.)*

ible shock waves traveling through or other gases. Work has been done this field before but the Navy's de- e has been specially developed for in new fields of microtime research. Named in honor of the late Dr. Al- t A. Michelson, noted American ysicist and Nobel Prize winner, the oratory is said to be the most com- ete scientific research facility of its pe in the world.

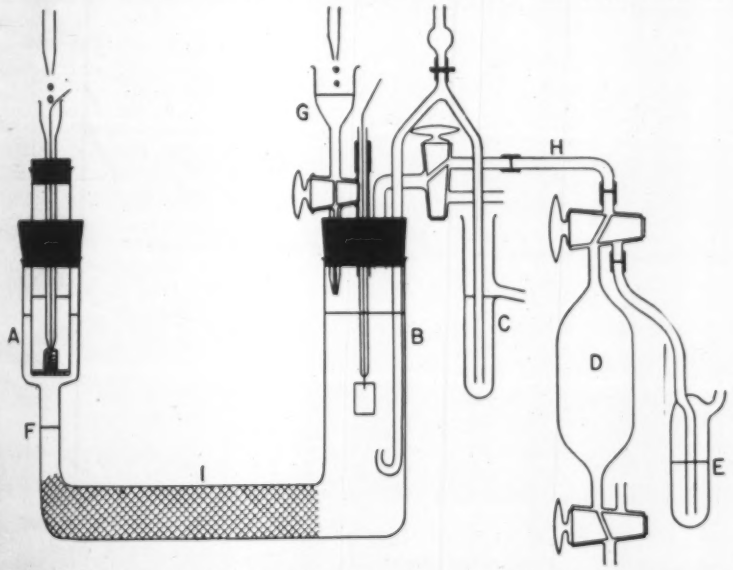
The Michelson Laboratory is virtually self-sufficient. Air-conditioned and earthquake-resistant, it contains extensive facilities for all types of basic and applied research in physical and chemical science, aerophysics, mathematics, electronics, metallurgy, propulsion systems for rockets and missiles, and fire-control and guidance systems. Research is under direction of Dr. L. T. E. Thompson.

Measurement of Current Efficiency in Electrochemical Processes

WASHINGTON, D. C.—According Technical Report 1154 of the Na- nal Bureau of Standards a new ethod for measurement of the current iciency of an electrochemical proc- s[1] has been developed by W. J. amer of the NBS in connection with ectrochemical studies of isotopes. The ethod is based on principles previous- utilized at the Bureau in the sepa- tion of natural isotopes by a tech- que known as countercurrent electro- igration,[2] in which an imposed flow electrolyte through a packing in a rection opposite to ionic migration rries back the slower moving ions of e heavier isotopes.

In many electrochemical processes multaneous reactions take place at an electrode. Where this occurs, the ratio of the number of equivalents of a single electrode product to the total possible number is called the current efficiency of the electrochemical process under investigation. Variations usually occur in ionic composition or concentration in the vicinity of the electrodes, due to electrolysis and ion transport. Because of such variations, precise values of the current efficiency cannot be obtained, and the process cannot be carried on continuously with either constant current efficiency or constant yield.

For example, when a concentrated solution of brine is electrolyzed between graphite electrodes, the over-all efficiency for the production of chlorine, at first 98 percent, may drop to only 50 percent, with an attendant increased cost of production.



Cell consists of a cathode compartment (A) and an anode compartment (B), sep- rated by glass wool packing (I) to pre- ent diffusion of electrolytic products rom one electrode to another. For a udy of current efficiency in the electrol- sis of uranyl chloride, the cell is first lled with the electrolyte up to the level F). A solution of hydrochloric acid is hen poured into the cathode compart- ent, forming a boundary with the urani- m chloride solution; this prevents con- amination of the electrolyte with reduced products of the cloride which might orm at the cathode. Finally, enough of he chloride is added to fill the cell. As electrolysis proceeds, known concentra- ions of hydrochloric acid and uranyl chloride are added drop by drop to the athode and anode compartments respectively, at such rates that the concentration and pH of the electrolyte remains constant, the excess being automatically siphoned off into the overflow (C). When the pH of the overflow becomes constant, indicating that the solution in the anode compartment has become saturated with chlorine gas, the gas in the anode is permitted to flow about for one-half hour through the tube (H) and the trap (E) to flush out all confined air. Samples of the gas are then slowly drawn into the evacuated pipette (D); at the same time the solution in the overflow is automatically drawn back into the anode compartment. The current efficiency of the process for the production of chlorine is determined from analysis of the collected gas by absorption in potassium hydroxide.

The apparatus developed at the NBS consists essentially of a cell with flowing electrolyte, in which there is no net transfer of ions and in which the concentration of the electrolyte is kept constant during the electrolysis. Current efficiency is thus maintained at the initial level.

This apparatus has been used to determine current efficiency, for various concentrations of electrolyte, in the electrolysis of uranyl chloride. The process takes place within a U-shaped electrolytic cell consisting of vertical anode and cathode compartments separated by a horizontal tube containing a porous glass-wool packing of diaphragm (see diagram).

Since production of chlorine by electrolysis of uranyl chloride may thus be continued indefinitely under controlled conditions, the method might well be adapted to the production of gases, such as chlorine, hydrogen, deuterium, and oxygen, in lots of known purity. It is also expected that, with some mechanical changes, these principles may be applied in the continuous refinement of metals and in electrolytic oxidation or reduction processes.

(1) Complete details of this work are given in a paper by W. J. Hamer, Anodic current efficiency in the counterflow electrolysis of uranyl chloride solutions, *J. Research NBS*, Vol. 39, 1947, page 141. RP 1817.

(2) Isotope separation by countercurrent electromigration, *NBS Technical News Bulletin, 31*, Vol. 31, 1947, page 49.

Testing Weapons Under Stratosphere Conditions

ABERDEEN PROVING GROUND, Md.—On May 17 the Army Ordnance Department dedicated, before high-ranking military personnel and some of the foremost scientists of this country, its new Stratospheric Facility for actual firing tests of aircraft guns and ammunition under simulated atmospheric conditions encountered in combat flight.

The new Stratospheric Facility, under construction since July 1945, is the largest firing chamber in the world capable of changes in temperature and atmospheric pressure from 70°F. and sea level pressure, at a simulated rate of climb of 5,000 feet per minute to 50,000 ft. altitude and 70° below zero and a pressure of about 1.7 lbs./in.^{2}. Descents can be simulated to speeds approaching that of the speed of sound.

Instruments record the velocity of each round from machine guns firing over a thousand rounds per minute. Temperature changes of fractions of a degree can be detected. Even the strains set up in the gun ports by the rapidly changing temperature are continuously recorded. High-speed movie cameras record the movement of the gun ports and can photograph the projectile in high-velocity flight. Rate of fire of these

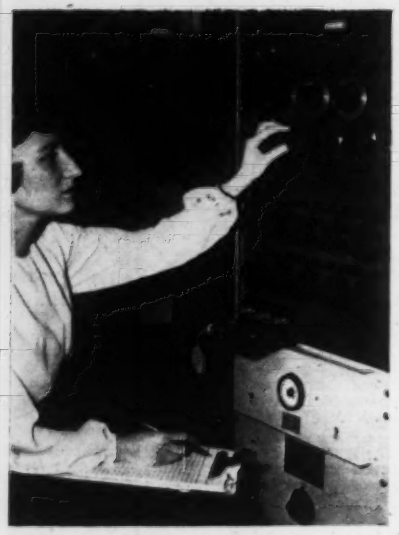
weapons is measured by special instruments at any altitude from ground level to 50,000 ft.

Effect of extreme cold on metals, fuels, lubricants and automotive parts can be determined in a section of this Facility which is capable of producing a temperature of 110° below zero.

Magnetic Amplifiers Improved by New Alloy

WASHINGTON, D.C.—Permenorm 5000-Z, a magnetic alloy which will make possible revolutionary changes in the rectification of electric power and in magnetic amplifiers, has been reproduced for the first time in the U.S. by scientists at the Naval Ordnance Laboratory, White Oak, Md.

The alloy, resulting from a fusion of nickel and iron under an intricate heat-treating process, was first synthetized in 1943 in Germany. Unfinished samples found in Germany by allied technical missions were brought to the U. S. and distributed to governmental and industrial laboratories to be duplicated for American use. Although details of the process were available, the metal could not be successfully duplicated because of the intricate heat-treating process required.



PERMENORM — At Naval Ordnance Laboratory Miss Elizabeth Davis tests a magnetic-amplifier core (label attached) made of the amazing new alloy, Permenorm 5000-Z. *(Official U. S. Navy Photograph.)*

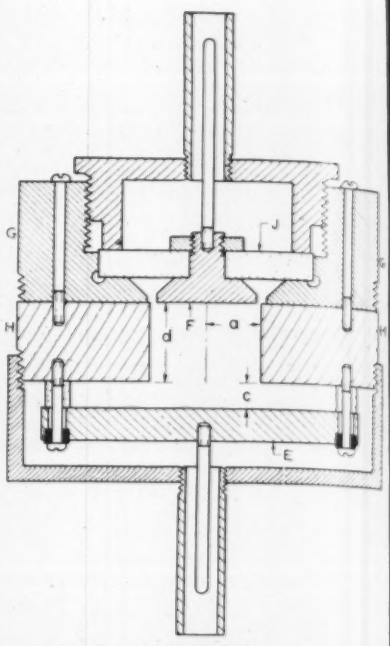
In addition to duplicating the German process, the Navy scientists developed a more satisfactory process for adapting the material to modern mass production techniques. They showed also that it has important application in the fabrication of magnetic amplifiers. In this application it is possible to replace many of the complicated, delicate and troublesome electron-tube amplifiers employed in guided missiles, fire-control equipment, and underwater ordnance. When used as replacement material for delicate electronic equipment, the alloy will make possible amplifiers for Naval ordnance that are more rugged and better fitted to withstand battle shocks and concussions.

Credit for reproduction of the alloy and its new applications goes to Dr. Gustaf W. Elmen and Mr. Edward A. Gaugler, physicists at the Naval Ordnance Laboratory. Dr. Elmen, inventor of Permalloy and Perminvar, discovered the magnetic properties of powdered iron dust and of iron, nickel, and cobalt alloys, and succeeded in producing a series of iron, nickel and cobalt alloys that are more easily magnetized and in other respects superior to iron and steel. He has been connected with the Naval Ordnance Laboratory since 1942. Mr. Gaugler is chief of the Magnetic Materials Laboratory of the Naval Ordnance Laboratory.

Standards of Very Small Capacitance

WASHINGTON, D.C.—In response to requests from manufacturers and users of electron tubes, the National Bureau of Standards has established standards and equipment for testing and certifying small fixed standards of capacitance ranging in value from 100 down to 0.001 micromicrofarads. This work, under the direction of Dr. Charles Moon, has involved the development of a series of primary reference standards and the construction of several fixed secondary standards and variable capacitors. For values below 0.1 $\mu\mu$f, a new type of primary standard capacitor has been designed, utilizing a principle which makes practical the construction of units having a capacitance as small as may be desired.

For capacitance below 1 $\mu\mu$f, use of the classical guard-ring design requires either that the diameter of the island be quite small or that the separation of the plates be very large. For this reason, a new type of guarded-electrode capacitor was developed for the range from 0.1 $\mu\mu$f down to 0.001 $\mu\mu$f on the basis of a design suggested by Dr. F. B. Silsbee of the NBS. In the new capacitor the guarded electrode, instead of being coplanar with the guard ring as in the Kelvin type, is placed at the bottom of a cylindrical well of fixed depth below the surface of the guard. Fringing occurs, depending on the depth of the well, so that only a fraction of the electric flux from the high-potential electrode reaches the measuring electrode. By increasing the depth of the well, the capacitance can be made as small as desired; at the same time the capacitor is of such dimensions that it can be constructed and measured accurately. The construction of the guarded plate and of the high-voltage electrode is identical with that of the guard-ring capacitor. Actually, the standard guard-ring type can be converted to the new design by addition of a ring of suitable thickness with plane parallel sides and containing a central hole having a diameter equal to the diameter of the island plus the width of the gap.



New type of guarded-electrode capacitor designed at the NBS. High-voltage electrode E is held at a fixed distance from smaller measuring electrode F, which is separated by a small gap from guard ring G. Increases in thickness of the additional guard H, by reducing the flux to F, decrease the measured capacitance to as low values as may be desired. Measuring electrode is accurately centered in guard ring by Pyrex-glass collar J. Capacitance is computed from measurements of the lengths *a*, *c*, and *d*.

Formulas for computing the capacitance of both types of capacitors have been derived by Dr. Chester Snow of the NBS. In addition to the primary standards, several secondary standards have been built.

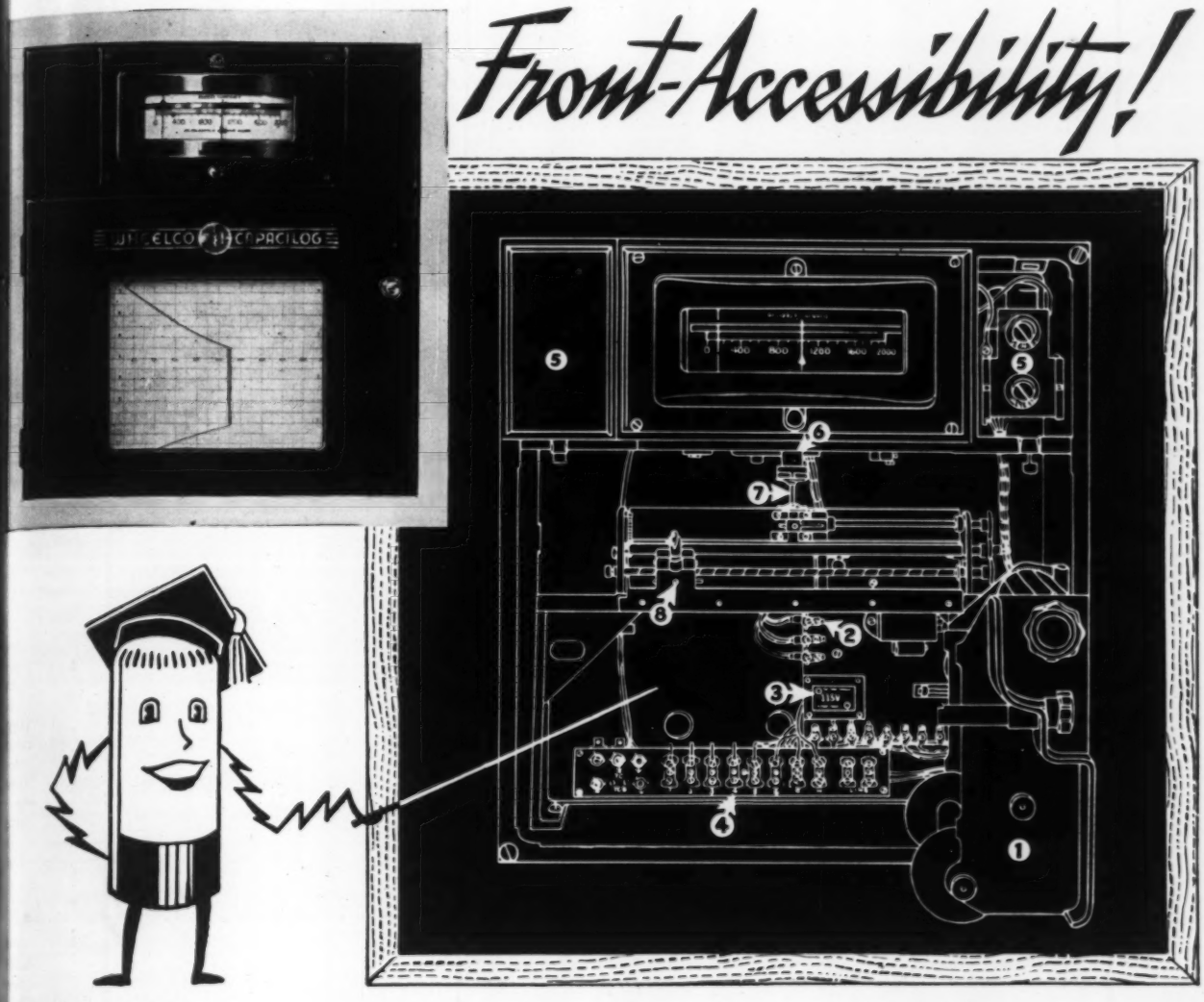
Machine-tool Instrumentation

PITTSBURGH, Pa.—"Control" was the keynote of this year's Westinghouse Machine Tool Forum held in Buffalo, N. Y., April 22nd and 23. Advances in instrumentation were reported by nearly all speakers. Brief extracts from some of the technical papers follow:

In *"Choosing D-c. Power Sources for Machine Tools,"* L. W. Herchenroeder, Industry Engineering Dep't, Westinghouse Electric Corp., compared with one another the three forms of conversion equipment normally used on machine tools: the metallic rectifier, which may be of the copper oxide or selenium type; the electronic rectifier; and the motor-generator set.

"Each has certain advantages and occasionally there is confusion as to the proper equipment to use for a given

Front-Accessibility!



Functional Parts Easily Accessible In CAPACILOG, "*Electronic Scriber*"

483

One needs only to open the door of the Wheelco CAPACILOG "Electronic Scriber" to be impressed by the simplicity of its construction. The instrument is completely front accessible. The strip chart assembly (1) swings out to give easy access to central motor drive terminals (2), voltage selector plug (3) and terminal panel (4). The electronic chassis (5), like the indicator are plug-in drawer type. The vertical drive shaft (6) is separable by means of a unique flexible coupling (7). A backlash adjustment (8) is mounted on the Pen Carrier.

These instrument refinements provide the ultimate in ease of maintenance and installation. To plant men the Capacilog represents the simplest and most economical system of measuring, controlling and recording process variables. Let us assist you in the selection of the proper measuring system and control arrangement for your particular application. Ask for Bulletin C2-1

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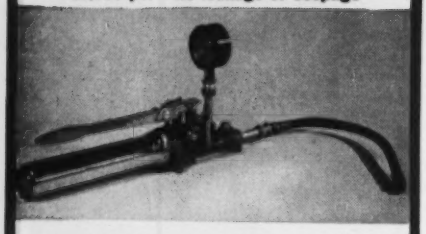
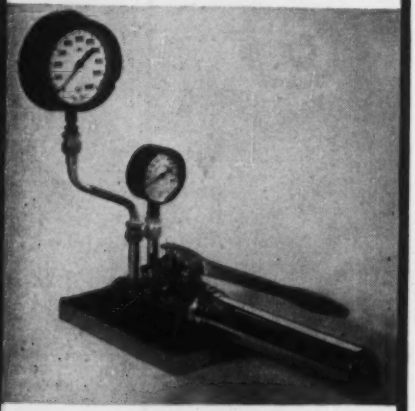
WILL SERVE 3 WAYS

10,000 psi—no leakage or seepage



1 PORTABLE PRESSURE TESTING
Weight, filled with oil, 8½ lbs.



2 BENCH WORK WITH TEST GAGE
mounted on aluminum drip pan

3 DEAD WEIGHT TESTING
shown with dead weight attachment mounted on unit.
Write for Bulletin

MANSFIELD & GREEN
1051 Power Avenue CLEVELAND 14, O

application," he said, "The problem can be simplified somewhat by reducing it to two parts: the first dealing with a general source of d-c. power for solenoids, magnetic chucks, etc.; and the second dealing with d-c. adjustable speed drives." He summarized important parts of his discussion into one graph and two tables, which are published herewith.

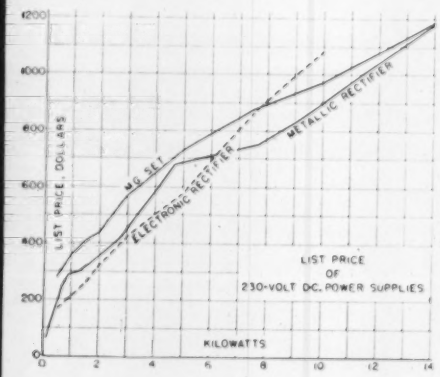


TABLE I—D-C. POWER SUPPLIES

	Metallic Rectifier	*Electronic Rectifier*	*M-G. Set*
Price	Lowest Except Cases to the Right	Lowest for 230 Volts ½ to 5 kw	Lowest Above 15 kw
Installation cost	1	1	2
Maintenance expense	1	3	2
Vibration	1	1	2
Voltage regulation	2	2	1
Ease of voltage adjustment	2	2	1

In the above 1, 2, 3 ratings, 1 is the most favorable

TABLE II—D-C ADJUSTABLE SPEED DRIVES

		Selenium	*Mototrol*	*Adj. Voltage*
Price	Constant torque	2	3	1
	Constant hp.	1	2	1
Speed range		4 to 1	40 to 1	16 to 1
Speed regulation		3	1	2
Positive slowdown		No	No	Yes
Smoothness of acceleration		3	1	2
Vibration	Power supply	1	1	2
	Motor	2	3	1
Motor Size	Constant torque	Increased frame size	Increase one frame size	Standard
	Constant hp.	Standard	Increase one frame size	Standard
Rheostat size		2	1	2
Maintenance		1	2	2
Installation cost		1	1	2

In the above 1, 2, 3 ratings, 1 is the most favorable.

"Oscillographic Performance Analysis of an Automatic Sharpening Machine" was reported in great detail by Frank A. Glassow, Application Engineer, Barber-Colman Co., who concluded: "Oscillographic measurements showed (1) that a separate switch originally used to de-energize the solenoid valve could be eliminated; (2) a more desirable design resulted when this operation was combined in one switch with the index drive mechanism control, in effect producing an electrical interlock; (3) the need for earlier actuation of the index drive mechanism control switch; (4) information concerning the range over which the adjustable tripping cam could be set without impairing operation for the range between 40° right and left helices and 4 to 26 notch index plates at all speeds of operation. The use of position indicating contacts on the machine mechanism avoided the need of accurate resistors and constant voltage in the oscillograph element circuits and required only that the oscillogram time scale be accurate."

Longest (18-page pre-print) and broadest-tone paper presented at the Forum was *"Turning Points in the Metal-working Industry"* by Myron S. Curtis, Assistant Director of Engineering, Warner & Swasey Co., whose opening theme was "We think that *production* is the *only* salvation of *any* civilization." He insisted that there are only two ways to increase production, to increase the productivity of the individual—either by having him work harder and produce more per hour as a result of his direct labor, or to provide him with tools of increased productivity, so that, with the same amount of work, he will produce more goods. The American way has always been to create more wealth, and provide a better standard of living for its workers, by providing more, better, and more efficient tools than other nations have.

"The productive capacity of any machine tool is controlled by two major factors. These are: machining time and *handling time*—the time required to load and unload the workpiece, to change speeds, bring the tools into position, etc. Attention must be given to both of these factors.

"Speed seems to have an overpowering attraction to us Americans, so let us look into the question of cutting speeds," said Mr. Curtis, who analyzed several problems and concluded: "We have proved to our own satis-

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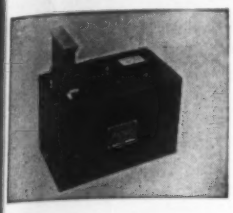

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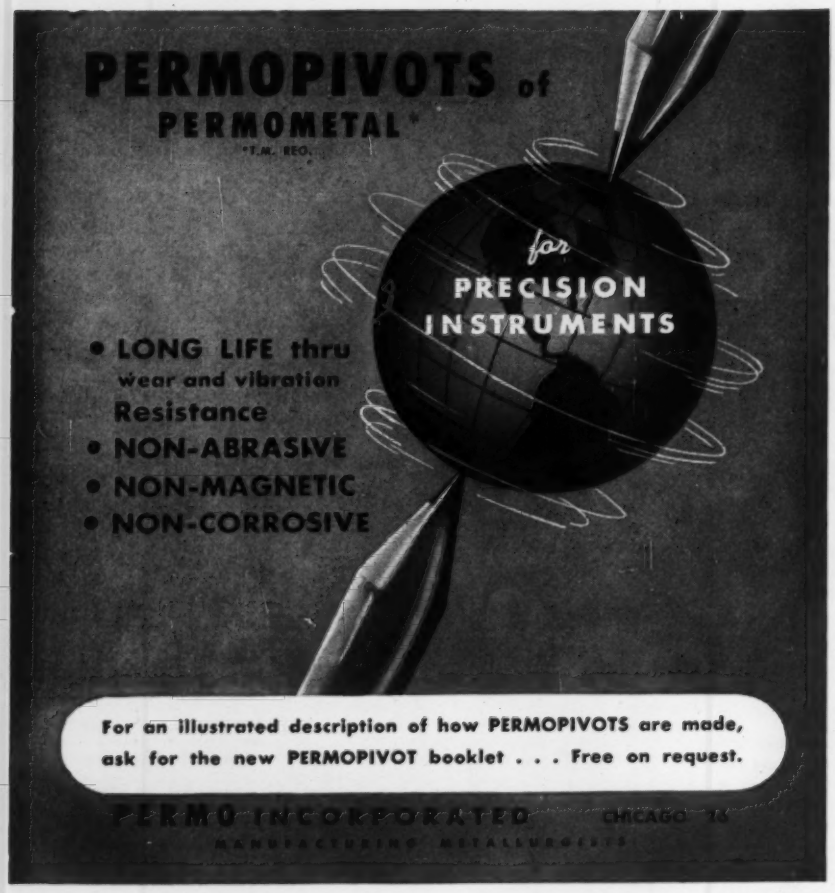

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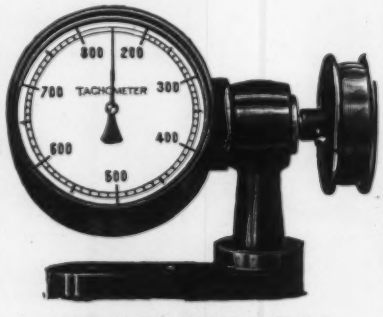

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faction that not only is high speed the greatest enemy of tool life, but in many cases it is responsible for lower production by increasing handling time or floor-to-floor time.

"The greatest advance in production efficiency was shown at the Machine Tool Show in the attention which had been paid to the reduction of handling time, in its broadest sense, and rightly so. We have found that the application of electric control whereby various handling operations such as spindle speed changes, etc., previously done manually, are now done automatically, increases the production efficiency of the machine from 30% up, as against an increase in production efficiency of 3% to 10% by having the exact cutting speed.

"These various machine functions can be accomplished mechanically, electrically or hydraulically, or a combination of methods. Be wary of the proponent who claims that hydraulics is the only solution, or the one who says that everything should be done electrically. As a matter of fact, there is a growing tendency to use a combination of methods, taking advantage of the good qualities of each."

"*A Recent Development in Automatic Lathe Control*," by E. P. Bullard, III, The Bullard Co., began with a general engineering discussion of a new 3-spindle automatic lathe developed to meet the need for a machine capable of automatically performing, with a minimum of special tooling, the large variety of turning operations normally done on a standard engine lathe. Extracts from the section on automatic control:

"An analysis of the functions performed by the man in operating any type of device, whether it be a lathe, an electric typewriter, or an automobile, shows that he must have three distinct abilities: (1) The ability to know *what* to do, including the sequence in which it must be done; (2) The ability to know *where* to do it in relation to other operations being performed; (3) The ability to perform simple mechanical motions, for without this power, knowledge itself can in no way change the speed of a lathe spindle, or cause an automobile to turn a corner. It must be emphasized that the power to perform the simple mechanical motions must come from the man himself, and not from the mechanism he is operating, since only by actual muscular movement, no matter how slight, is man able to transfer his thoughts.

"The Man-Au-Trol, which means manual and automatic control, was developed to provide a control for any mechanism similar to that supplied by the man. The device consists of three fundamental parts, each of which supplies one of the abilities referred to above: (1) The function control drum, on which a pattern of any desired sequence of functions of which the machine is inherently capable, may be

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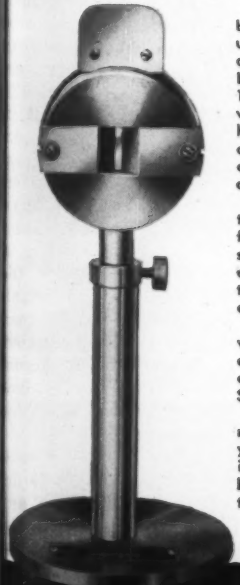

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST

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NEWPORT, RHODE ISLAND, U. S. A.

An Improved MANOMETER CHECK VALVE

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This unit more than repays its cost by preventing loss of indicating fluid and saving labor in re-servicing equipment. It also protects the manometer against high pressure surges.

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set up. The function control d um the determines what functions th machin is to perform, and in what sequenc (2) The function stop dogs a l attend ant switches, which may be adjuste to determine where a funct on is t take place. (3) A hydraulic and elec trical system provide the po ver, co responding to the muscular power o the operator, to engage th various gears and clutches with which the ma chine is provided.

"The controls are groupe at th right of the 3-spindle lathe, as men tioned above, and consist of two dia at the top which control the motion o the slide and the saddle; a lever t choose either manual or automatic con trol; and, in the case of manual con trol, hand feed and traverse lever and a rheostat for speed control. A tachometer gives direct speed reading

"Three foot treadles, one for eac spindle, leave the operator's hands fre during loading and unloading. As eac treadle is pressed, hydraulic pressu first pulls the centers together unt the work is picked up, then activate hydraulic drivers which grip the wor under uniform pressure."

In discussing *"The Application o Instruments to the Machine-tool Indu try,"* Roy J. Teetsell, Instrument Spe cialist, Westinghouse Electric Corp declared that for adequate applicatio "instruments must be placed directly a the point from which the machine operated, and the current consumptio power, speed and other operating fa tors, must be under direct observati of the machine-tool operator."

"Instruments cut down unit lab costs. The hard-to-get skilled operat can get by with little instrumentati but with adequate instrumentation t skilled can do a more efficient job a the semi-skilled can often perform th same job and just as well.

"Furthermore, instruments serve a a ready indication as to whether or no the set-up man or operator is using th machine at its maximum utility.

"Electrical instruments being used b machine builders are:

"(1) Miniature panel type instru ments are commonly used where spa is at a premium.

"(2) Switchboard instruments—Th 4¼" square case with circular scale becoming more popular.

"(3) Socket type instruments, use where there is no space for a pan near the machine. One type of rece tacle consists of a die cast ring designe for mounting as part of the machin tool itself. A circular-chart recorde and a watthour meter are made tha will plug in this socket; also a jack t permit the use of portable test instru ments.

"(4) Tachometer — A-c. tachomet generators used with rectifier type i struments are replacing the d-c. ty tachometers because there are no brus es or commutator to maintain.

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The exposed mechanism shows how synchronization of the two elements is obtained. Thumb control knob "A" is geared to the fabric selection pointer visible in small photo. It also restricts movement of temperature regulating element "B" and regulates the heat in the plate. Temperature indicating element "C" reacts to plate temperature and rotates shaft "D" to which vari-colored dial is attached. When yellow background reaches pointer, heat is correct; too hot and too cold are indicated by red and green areas. (The internal linkage mechanism has been omitted for clarity).

Again, as in many other heat responsive devices where temperature control is vital, Chace Thermostatic Bimetal is specified as the actuating element.

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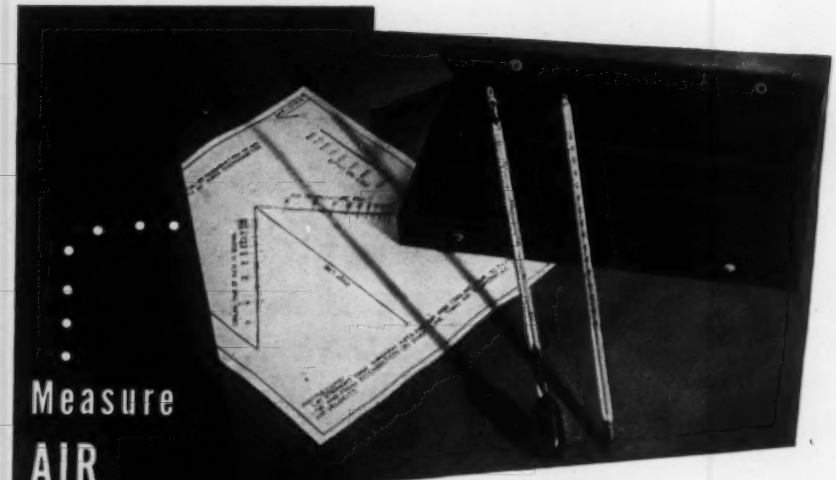

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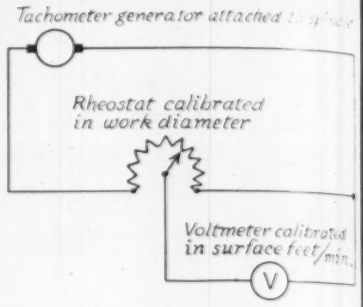
ments on machine-tools described by Mr. Teetsell were: (1) Lathe with panel-type a-c. ammeter is used calibrated in hp.; (2) automatic machine with switchboard ammeter calibrated in percent load; (3) Variable-speed turret lathe using a tachometer [see diagram]


Tachometer generator attached to spindle
Rheostat calibrated in work diameter
Voltmeter calibrated in surface feet/min.
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"(2) The d-c. industrial analyzer is a companion to the a-c. analyzer and in general performs the same function.

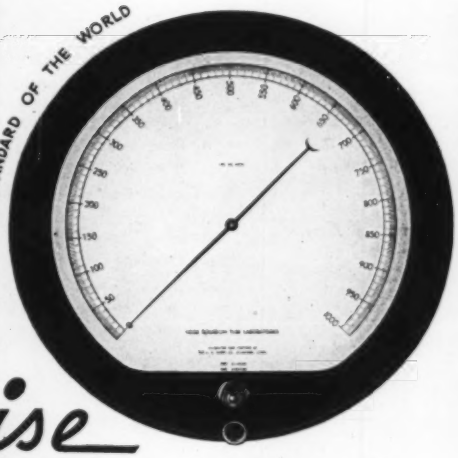
"(3) A-c. and d-c. test set, pocket size, with a-c. and d-c. voltage and current ranges and ohm scales.

"(4) Often a single self-contained ammeter having full-scale ratings of 2 to 200 amperes is found to be the most universal instrument for load current measurements. With it a triple range voltmeter will often suffice.

"(5) Recording instruments, round or strip-chart type. For maximum utility a general-utility wattmeter which can be used on either a.c. or d.c., having a triple voltage range of 115, 230 and 575 volts, and a 5-ampere current coil which can be used with either the 5-ampere secondary of a current transformer, or a 100-millivolt shunt, is recommended

"These five types of instruments and their necessary auxiliaries keep test instrument requirements to a minimum and at the same time provide the right instrument to do the job.

"Going a step further toward maximum plant efficiency, we could find that instrumentation might well serve industry as a real gage of productivity if instrument readings are brought to a central supervisory point. For a machine tool, instruments can be an absolute index of (1) intervals between work operation, or (2) down time for repairs and adjustment, (3) check on machine operation, (4) a complete graphic picture of a day's work, (5) a graphic record of a first run operation or an operation that does not



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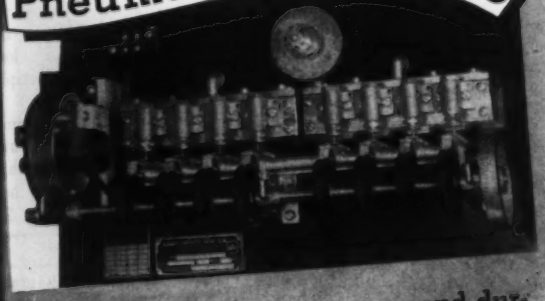

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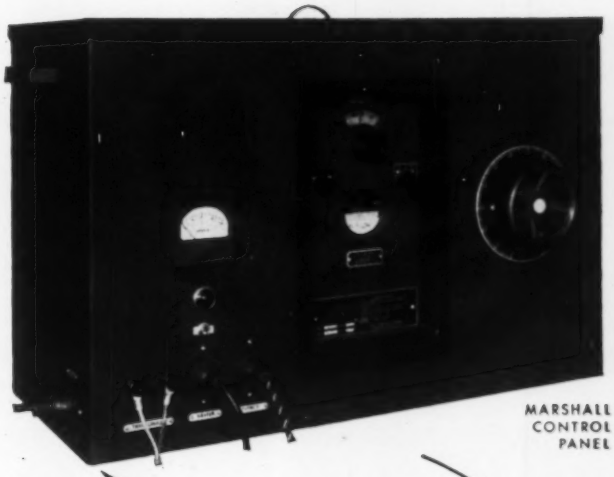

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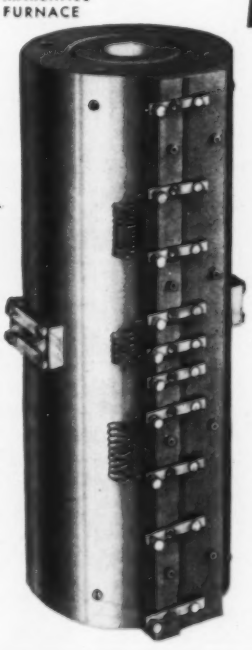

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occur too frequently, which can be of value in the immediate or distant future. Some installations are simple; others more complex and necessarily would have to be done gradually.

"We know from past experience in other industries how once instruments began to be used, the results justified their increased use many times over. With these thoughts in mind it can be predicted that electrical measuring instruments will soon become the eyes of the machine-tool industry."

"Electrification of a Tracer-controlled Milling Machine" was discussed by J. J. Jaeger, Electrical Engineer, Pratt & Whitney Div., Niles Bement-Pond Co., who said that the vast scope of work presented to this type of machine for Kellering calls for a control system capable of simple selection of the varied modes of operation demanded. The particular machine he discussed was created to Keller the large stamping and forming dies of the automotive body industry. It can cover a die area 5 feet by 14 feet in a single set-up. It is not unusual for a die to weigh 50 tons, which is the approximate weight of the complete machine.

"The fundamental Keller tracer control," said Mr. Jaeger, "is extremely simple and reliable and can easily be serviced by the average shop maintenance personnel. Depending on the size and speed of operation of the machine, over-all profiling accuracy of duplication is from 0.002" to 0.008" and on three-dimensional work from 0.005" to 0.015". The accuracy of repetition is substantially better. These figures include all normal errors of mill shape and spring. It is also important to realize that on the size machine under consideration the limitation of accuracy is more often the wood or plaster models.

From *"Electronic Lathe Controls"* by Kermit T. Kuch, Vice President—Engineering, The Monarch Machine Tool Co.:

"During recent years it was practically impossible for electrical manufacturers to devote any great amount of time to the individual requirements of certain user applications.

"The only unit small enough to fit the space available in the toolmaker's lathe employed single-phase, full-wave rectification. The reserve needed to accelerate the spindle, as well as to take care of occasional overloads, simply was not present. The bulky piece of equipment utilized every available bit

WHEN A FELLER NEEDS CONTROL

By Phil Putnam

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GET TH' INSTRUMENT DEPARTMENT— RUSH SERVICE JOB! HURRY! HURRY!
H-O-O-E-E-E-E-E-
INSTRUMENT SERVICE
C'MON! C'MON! WHAT TOOK YA SO LONG?!!
G-GOSH! THIS MUST REALLY BE TROUBLE!!
INSTRUMENT DEPARTMENT
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IDEA BY: EDW. I. BROWN POLYMER CORP. LTD SARNIA, ONTARIO CANADA

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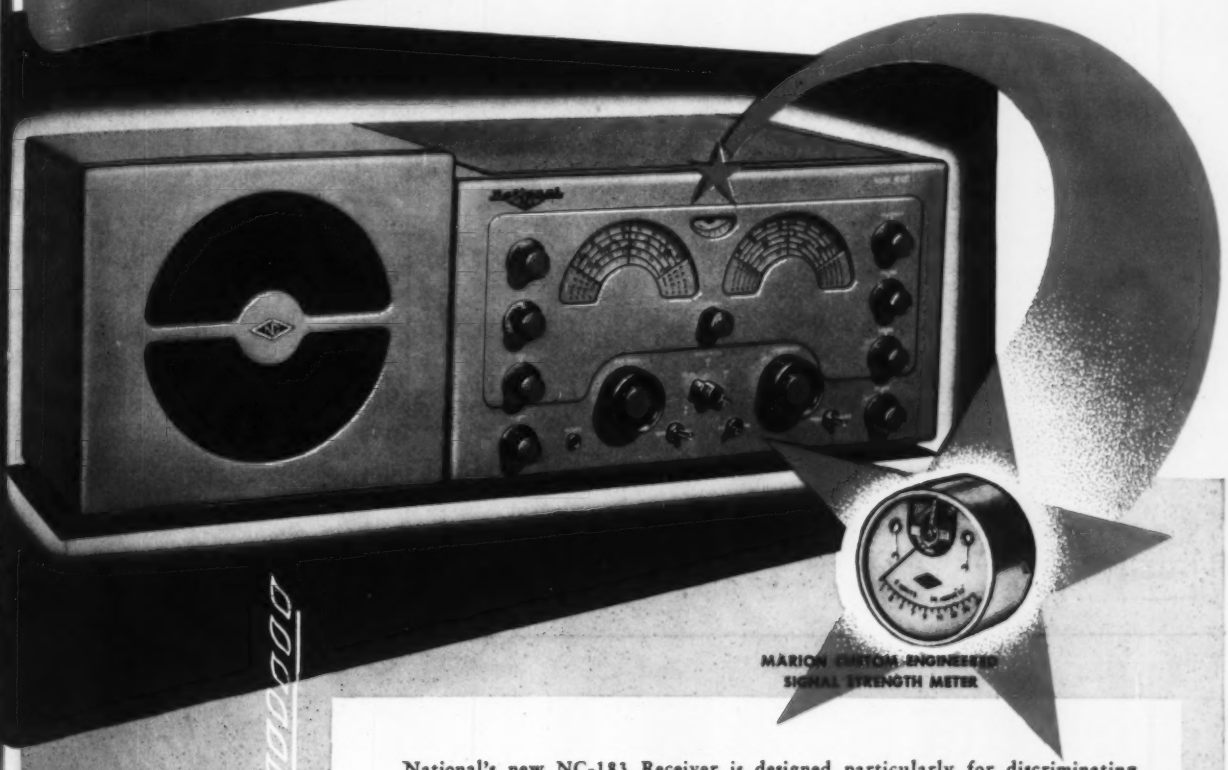

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Every demand was made by the National Company that components used in this brilliant, new receiver be consistent with their established reputation for building fine communications receivers.

The Marion Electrical Instrument Company designed a special S-Meter for the NC-183 to answer National's demand for quality . . . radio operators' demand for an accurate, dependable means of measuring and logging signals being received.

This "special" has an unbreakable plexiglass, anti-static coated window and Marion engineered dial illumination that eliminates the two principal drawbacks of conventional dial lighting . . .

A transparent lucite cavity for the bulb *seals* the delicate mechanism from dust drawn in by thermal currents and *prevents* insertion of oversized replacement bulbs which often damage the meter movement.

In addition, this "S-Meter" incorporates a special zero set in the *back*, in addition to a dust seal and other features available in all Marion Standard Electrical Indicating Instruments.

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of space in the base of the machi was divided into a number of units a mounted separately which, of cour introduced assembly and maintenan difficulties.

"Another unit, employing thre phase rectification, was quite an i provement electrically, but so lar that it had to be housed in a separa control cabinet which almost equal that of the lathe, and naturally a ve substantial price was not missing.

"Our electrical engineers decided try their own luck at developing a tu control for this application. The fi attempt was made with two mercur vapor tubes having a maximum rati of 12 amperes, but operating tempe ature limits of these tubes were t narrow. When a 16-ampere xenon-fill tube became available, our circui were immediately modified to empl these tubes and a new unit was p under test which, after a few mont of further refinement, resulted in t control we have today. To make t unit accessible for maintenance, t chassis was mounted on a roller-bea ing suspension so the entire unit cou be rolled out from the machine base.

"Far from feeling that we ha reached the ultimate in the design a application of electronic controls to t turning machines, we are daily becom ing more convinced that there is great deal more which can be do with them than has yet been tempted."

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JOURNAL of the Instrument Society of America

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Vol. 3 — June 1948 — No. 6

General News

Executive Committee Meets in Saint Louis

The Executive Committee met in St. Louis at the Hotel Jefferson on April 24, 1948. The Recommended Practices Committee and the Finance Committee met on the 22nd and 23rd, reported to the Executive Committee briefly and continued work on the 24th. No reports are out yet on the work accomplished by these groups but they may be available in time for the July issue.

Membership and Sections Committees

Since the duties of these two committees overlapped, the Executive Committee in January 1948, decided to combine the two and have the same personnel do both jobs. Chairman J. B. McMahon has prepared an outline of the duties of his committees, which expands the one published in the Journal for March 1948 and tries to answer the tough questions these men will be asked. A tentative division of the sections has been made and each committee member has a list of nearby sections to assist when needed.

The personnel of these committees is: Chairman, *J. B. McMahon*, Republic Flow Meters, Chicago, Illinois; *Paul G. Exline*, 710 South Troost St., Tulsa 5, Okla.: *Richard Rimbach*, 1117 Wolfendale St., Pittsburgh 12, Pa.; *Nelson Gildersleeve*, Special Products Div., General Electric Co., One River Road, Schenectady, N. Y.; *H. H. Barnum*, 16554 Pierson, Detroit 19, Mich.; *J. H. Gottrell*, P. O. Box 1807, Tulsa 1, Okla.; *Yeatman Anderson*, Foxboro Co., 607 American Bldg., Cincinnati 2, O.; *Henry Schmitt*, Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Pa.; *R. E. Hansen*, Leeds & Northrup Co., 718 Petroleum Bldg., Houston, Texas; *Dr. A. O. Beckman*, National Technical Laboratory, South Pasadena, Calif.; *T. E. Bell*, Republic Flow Meters Co., 150 Nassau Street, N. W., Atlanta, Ga.; *M. S. Jacobs*, M. S. Jacobs and Associates, 802 Bessemer Bldg., Pittsburgh, Pa.

Help for Those Organizing New Sections

Out of the experience of the past few years, the Sections Committee has available a write-up entitled "Suggestions on Organizing A Local Section of The Instrument Society of America." Prepared by Chairman J. B. McMahon, copies can be obtained by writing to him at Republic Flow Meters, Chicago, Illinois. For those groups planning to organize or convert into an ISA Section, this write-up should prove helpful and eliminate many of the pitfalls that sometimes slow up a new section

ISA Member Designs Alarm for Static in Operating Rooms

Raymond C. Webster, a member of the Kansas City Section, has designed and built a device to warn of excess static in hospital operating rooms. He fashioned the device according to conditions outlined by Dr. Paul H. Lorhan, of the anesthesiology department of the University of Kansas Medical Center.

The device is about the size of a small alarm clock and emits a buzing sound when static voltage rises to about 2000, although the danger point, where a spark is believed imminent is 4000. While the danger of death from a spark igniting the ether-oxygen mixture in a patient's lungs is remote, such accidents have happened, and doctors attending a meeting of the American Society of anesthesiologists in Kansas City on April 5, 1948, were much interested in the new protective device.

—*From The Kansas City Star.*

Calendar of Events

The calendar is being discontinued for the summer. Only a few sections have June meetings and details are not available on enough of them to warrant publishing the calendar.

To All Section Secretaries

Following are the changes and additions to the list of Section Secretaries, Directors and Journal Correspondents published in the Decembre 1947 issue of the Journal:

Chicago: New Executive Secretary . . . *F. E. Ertsman*, 506 South Wabash Ave., Room 611, Chicago, telephone Harrison 6448. New Director . . . *R. R. Proctor*, 2213 Ridge Ave., Evanston, Ill.

Tulsa: New Director . . . *J. E. White, Jr.*, Stanolind Pipe Line Co., Capital Oil Bldg., Tulsa, Okla.

Wayne County: New Director . . . *George Huff*, 777 Winchester, Lincoln Park 25, Michigan.

Section News

ARUBA

Igor Broz of the Technical Service Dept., Aruba Refinery, presented a two-part program at the March 2nd regular meeting. The first part "Liquid Petroleum Gas Process" covered a process recently added to the Aruba refinery. The second part was entitled, "At What Stage in the Design of New Units, the Subject of Instrumentation is Considered." He pointed out that instruments are considered early in the design but plans are quite often revised and it is not unusual for the instrument designs never to quite catch-up to these changes.

LEROY L. McGREW, *Corr.*

CALIFORNIA

Two features were on the program for the May 4th meeting. Mr. Donald C. Erdman, Electronics Engineer of Triplett & Barton, Inc. discussed "Supersonic Echo-Type Flaw Detectors." The talk was illustrated with slides and a new portable test unit was demonstrated.

The other feature was a showing of the U. S. Navy film of the atom bomb test at Bikini Atoll.

CENTRAL INDIANA

The May 4th meeting of the Central Indiana Section was held at the Indianapolis Central Library.

A very interesting two part talk, entitled "Modern Concepts of Gaging Practice," was given by Messrs. Witt and Mahlmeister of the Sheffield Corporation.

The subject covered the field of machine type gages for production testing, including the new types and the modern practices in the use of gages.—E. E. TAYLOR, *Corr.*

CHARLESTON

Thirty-four reservations were made for the dinner preceding the May 3rd meeting held at the East Side Woman's Club. A brief business session conducted by Section President L. F. Keppler gave opportunity for final announcements of the '47-'48 season. Only monthly executive council meeting will be held during the summer. Program Chairman C. G. Fellows explained the feature attraction of the first fall meeting. Due to the National Convention during the first week in September, October 4th will be the opening meeting. At that time a demonstration of the application of control instruments to process will be given by a representative of the Taylor Instrument Companies. The section membership at present stands at eighty-nine with a campaign planned for the fall.

This was the biggest meeting of the year; more than 125 members and guests were in attendance for the speech of the evening. Represented in that number were refineries from a radius of 75 miles, as well as the President of the Pittsburgh section, Mr. S. W. Prince. A new technique in refinery systems was explained by Dr. D. J. Bergman, Universal Oil Products. With the aid of a glass model, slides, and a wealth of information from his own background, fluid catalyst plants were most ably discussed. —MARY K. ADAMS, *Corr.*

CHICAGO

The annual business meeting and social event of the Chicago Section was held on Friday evening, May 7, at the Furniture Club of America in Chicago. Nearly 200 members, guests, wives and friends enjoyed the excellent food and entertainment, and witnessed the intallation of new officers for the 1948-49 season.

Following the dinner, President Stan Gray presented the annual President's message and then introduced the new officers, namely:

President . . . *Ralph R. Siechen*, Universal Oil Products Co.
Vice-President . . . *J. H. Cuthbert*, Carnegie-Illinois Steel Co.
Treasurer . . . *C. C. Hurst*, Garden City Instruments Co.
Director . . . *R. R. Proctor*, Pure Oil Res. & Dev. Laboratories.
Executive Secretary . . . *F. E. Ertsman*, 506 South Wabash Ave., Room 611.

After the business amenities, dancing and entertainment completed the evening, as well as the season. The next meeting will be held in September, the exact date to be annnounced later.

—R. R. PROCTOR, *Corr.*

CINCINNATI

The May 24th regular meeting was held at the Engineering Society Headquarters with Mr. Lyman H. Allen, Jr., American Viscose Corp., presenting a talk on "Automatic Control of Fractionating Columns."

The new officers installed at this meeting were:

President . . . *T. L. Clift*
Vice-President . . . *J. H. Hocker*
Recording Secretary . . . *Marvin Markert*
Corr. Secretary . . . *Smith Hickenlooper, Jr.*
Treasurer . . . *R. F. Romell*
National Director . . . *G. W. Brown*

—R. F. ROMELL, *Corr.*

CLEVELAND

At the Annual Election of the Section held on April 28, 1948, the following officers were elected for the 1948-1949 Season:

President . . . *A. A. Hejduk*, Vice President, Meriam Instrument Co.
Vice-President . . . *R. N. Hobart*, Republic Steel Corp.
Secretary . . . *L. H. Waldrip*, L. H. Waldrip Co.
Treasurer . . . *L. Johnson*, Arthur G. McKee & Co.
National Delegate . . . *A. J. McCullough*, The Brown Instrument Co.

The final meeting of the Spring will be held at the Cleveland Engineering Society on May 26th, which will feature a talk by Mr. John R. Green of The Brown Instrument Company whose subject is: "Instrumentation and Control in the Steel Industry."

Following graduation from the University in Illinois in 1922 as a Ceramic Engineer, and working in this field for two years, Mr. Green joined the Brown organization in 1924. He has served in a sales engineering capacity in their Chicago, Indianapolis, and Cincinnati offices, as well as in the field of sales management in Philadelphia and Pittsburgh. Since 1940, as Manager of the Steel and Ceramic Division, he has been closely associated with the development and application of industrial instrumentation for those industries on a national basis.

Mr. Green will give us a review of recent developments in the design of instruments for Steel Mill applications and the fundamentals of automatic control methods. Types and Mediums are also analyzed in relation to typical producing units. Instrument requirements for Blast Furnace, Open Hearth, Heating Furnace, Rolling Mill and finishing operations are discussed from the viewpoint of selection and application to secure the best practical results.

Following the meeting, there is to be a social session for members and guests with sandwiches and refreshments "on the house," and an opportunity to get better acquainted with one another.

CUMBERLAND

The Cumberland Section held its regular monthly dinner-meeting on Tuesday, April 27, 1948 at the Algonquin Hotel.

The speaker was Mr. Albert F. Sperry, President of Panellit Inc. Mr. Sperry spoke on "Automatic Controllers and Servomechanisms." His talk was very informative and interesting. Since he started with basic circuits and reasoning there were none who could not follow his explanations.

After the talk, nominations were open for officers of the coming year. The election will be held at our next meeting which will be followed by a social gathering. The details are not complete as yet.

—G. W. Harrison, *Corr.*

DETROIT

The April 20th meeting featured Mr. Lyle Eige, Fisher Governor Company, who discussed self-operated controllers. His slide illustrated talk covered the basic fundamentals of these very important pressure regulators. He showed the working principles, the points of construction, and the means used to compensate for the natural errors present in some types of diaphragm controls. His talk was on the basic design of the controllers rather than on the mathematics of their operation, and explained how they work rather than how to design them.

The May 18th meeting was addressed by Wm. T. Bean, Jr., Continental Aviation & Engineering Corp., on "Instrumentation for Experimental Stress Analysis". Experimental stress analysis recognizes the limitations of classic stress formulae and does something about it. Actual stress measurement on full size or scale models can determine load carrying ability without costly testing to failure. By utilizing this new engineering tool the length of experimental and development programs can be drastically reduced.

Mr. Bean demonstrated instrumentation for the three principal methods of experimental stress analysis; Brittle lacquer, photo-elasticity, and strain gages. Various types of strain gages, circuits and techniques for both static and dynamic testing were covered. In addition basic instrumentation for a stress laboratory and the selection of proper analysis technique was discussed.

—Ralph Hoxie, *Corr.*

EASTERN NEW YORK

The meeting on Tuesday, April 6, 1948 at Siena College, Loudenville, N. Y. had an excellent turnout of over 40 members and guests.

After a few committee reports and section commencements the meeting was turned over to the speaker of the evening, Mr. C. B. Moore, of the Moore Products Co., who spoke on "The Solution of Instrumentation Problems by the Pneumatic Null Balance Method."

Mr. Moore presented an excellent talk complete with slides, and inasmuch as this method of measurement was new to most of those present the discussion period was quite lively. Mr. Moore had a few models of this type of equipment with him and much interest was shown in these also.

—W. J. Claffie, Jr., *Corr.*

GULF COAST

The Gulf Coast Section held its May meeting at the Magnolia Petroleum Company Instrument Shop. The members inspected each section of the shop, which is one of the most up-to-date shops in the area. Later, refreshments were served at Fuller's Drive Inn. Mr. A. V. Wafer was appointed chairman to replace C. C. Weir. Mr. D. T. Gunter was elected Director of the section. There were about forty-five present.

The next meeting will be held September 21, 1948, at Lamar College Science Lecture Room.

—A. E. Bunn, *Sec'y-Treas.*

KANSAS CITY

On April 27th the Kansas City Section met at the Laboratory of the Corps of Engineers, Department of Army, Kansas City, Missouri. Col. Paul D. Berrigan, Officer in Charge, and Mr. K. V. Taylor, head of Embankment and Foundation Design Section gave preliminary talks on the works of the Corps of Engineers, and then assisted in explaining and demonstrating the various phases of testing performed in their laboratory.

—W. A. Reichow, *Corr.*

LOUISVILLE

The April 27 meeting of the Louisville Section was held in the rathskeller of the Horseshoe Grill, Louisville. Wives and girl friends accompanied members and prospective members.

The chicken and steak dinner was followed by a novelty act featuring a talented, local girl ventriloquist, Norma Jarboe. She, with her dummy, Junior, proceeded to make dummies out of E. H. C. Brown, John Caswell, T. P. Grose, I. Lefkowitz, Melvin Johnson, Joseph Monahom, "Bob" Wilkenson and Paul Smith to the delight of the rest of the membership. Val Gene Huffman was the only one who could find a suitable comeback for this rather shy young lady's impertinent "Junior".

Mr. Louis Aker introduced the main speaker Mr. Sid Park of Park Aerial Survey, Inc., who spoke on Aerial Photography. The conventional aspects of this subject were explained as well as new and novel developments such as the use of this medium in locating oil beds and mineral deposits. The program was the first of its kind attempted by this Section and was definitely a success.

At the May 25 meeting Mr. C. B. Moore of Moore Products Company will present a lecture entitled, "The Solution of Instrumentation Problems by the Pneumatic Null Balance Method".

—Paul B. Smith, *Sec'y.*

NEW JERSEY

The regular monthly meeting of the New Jersey Section was held at the Essex House in Newark, New Jersey, on April 6, 1948.

A regular business meeting was held prior to the start of the evening program. Nominations of officers for the coming year were made by the nominating committee.

A discussion of the investigations made by our Educational Committee took place after the chairman of that committee outlined what might be accomplished by the New Jersey Section sponsoring training courses for members. Indications are that one of our local Engineering Schools would be interested in providing facilities for presentation of a technical training course on Instruments and Controls.

In accordance with past practice this Section set aside this meeting as a forum night. Several interesting discussions were heard. From the amount of audience participation it can be concluded that this type of meeting will continue to be successful in the future.

—Harold M. McCarthy, *Corr.*

NEW YORK

Dr. Ralph Muller, New York University, presented a discussion of "Trends in Analytical Instrumentation" at the April 28th meeting. His talk included a survey of recent instrumentation and developments, mainly in the chemical analysis field, with a description of the process instruments used and the result obtained. In particular, Dr. Muller described a new development in which he has been quite active—Flowing Chromatography, a valuable method for the detection and isolation of specific homogenour chemical compounds (both inorganic and organic). This separation can be made for compounds similar in chemical structure and reaction, including hormones, vitamins, enzymes, and dyes.

The May 26th meeting was devoted to a panel discussion of everyday problems encountered in the measurement, indication, recording and control of temperature. Mr. Joseph M. Bilisoly of The Dorr Company acted as chairman and the board of experts included both users and manufacturers.

NIAGARA FRONTIER

The April meeting of the Niagara Frontier Section was held on Monday, the 26th at the New York State Institute of Applied Arts & Sciences in Buffalo, N. Y. After a short business meeting, President Clarence Boltz turned the meeting over to George Kellner, Chairman of the Nominating Committee, who conducted the election of officers for the coming year.

Clarence Boltz, National Aniline Division was re-elected as President. Other officers elected were as follows:

Executive Vice-President . . . *Joseph Hildyard*, Hooker Electro-Chemical Co.

Second Vice-President . . . *J. A. Ekhardt*, Wickwire Spencer Steel Company.

Secretary . . . *Kenneth Fees*, Carborundum Company.

Treasurer . . . *George Kellner*, Linde Air Products Company.

Board of Directors . . . *John Duthie*, Du Pont Co.; *Dr. A. Nadelman*, International Paper Co.; *John Meyer*, Semet Solvay Co.

Installation of officers will be held at the May 24 meeting.

—W. J. Somners, *Corr.*

PHILADELPHIA

On Wednesday, April 21, the Philadelphia Section of the ISA held their 56th meeting at the Penn-Sheraton Hotel. The speaker of the evening was Mr. William Welch II, Assistant Vice President of the Bell Telephone Company of Pennsylvania. The meeting was called by President Garner Parr who introduced Mr. Welch and paved the way for one of the most interesting evenings the Society has had.

The subject of the evening's talk was "High Waves of Communication". Mr. Welch, assisted by Mr. May, gave a very forceful demonstration of the transmission of sound using electro-magnetic waves of extremely high frequency and short length. One may get an idea of the types of waves discussed by Mr. Welch's opening statement in which he stated that the ordinary wave length of our 110 volt 60 cycle current is approximately 3 miles long as compared to the wave length of 3 centimeters in the high frequency short wave that he demonstrated. One of the peculiar phenomena of this type of wave is that it will pass through normal electrical insulators but will be stopped by common metal conductors. It is also possible to polarize the waves. Since the waves travel in straight lines only and do not follow the curvature of the earth, it becomes somewhat of a problem to transmit sound via this method when obstructions lie between the transmitter and receiver. It is possible, however, to pipe them and Mr. Welch gave a very complete demonstration of the methods of piping and the ability of the waves to travel through various types of ducts, pipes, flexible hose, etc.

Mr. J. E. MacConville, Chairman of the Social Committee, made a short announcement after the meeting confirming the annual dance which will be held at the Cynwyd Club, Friday, May 28. Any visitors from out-of-town chapters planning to be in Philadelphia at this time should include this in their itinerary. A meeting will be held on June 16th at the Penn Sheraton Hotel with dinner at 6:30 P.M. The meeting, Philadelphia Section Night, will convene at 8:00 P.M.

—John C. Koch, *Corr.*

PITTSBURGH

On Monday, April 26th, about 80 members and guests of the Pittsburgh Section gathered at the Carnegie Library Lecture Hall for the regular monthly meeting. Before the meeting, a group of 50 dined in the Carnegie Institute Cafeteria.

The meeting was opened to business by President S. W. Prince at 7:55 P.M. The previous meeting's minutes were read by Secretary L. M. Susany, who also reported that 6 new members had been admitted making a total of 182 members. Treasurer Clarke Frye reported on the Section's finances, and Al Shafer said a few words about the St. Louis meeting of the ISA National Board.

Wayne Farley, reporting for Election Committee Chairman A. B. Powell, announced the officers elected for next year, who will be inducted at the May meeting:

President . . . *R. M. Kendig*—Westinghouse Airbrake.

Vice-President . . . *C. B. Cochrane*—Peter Loftus Eng. Co.

Secretary . . . *L. M. Susany*—Carnegie Institute.

Treasurer . . . *C. E. Frye*—Westinghouse Electric Corp.

(Continued on Page 564)

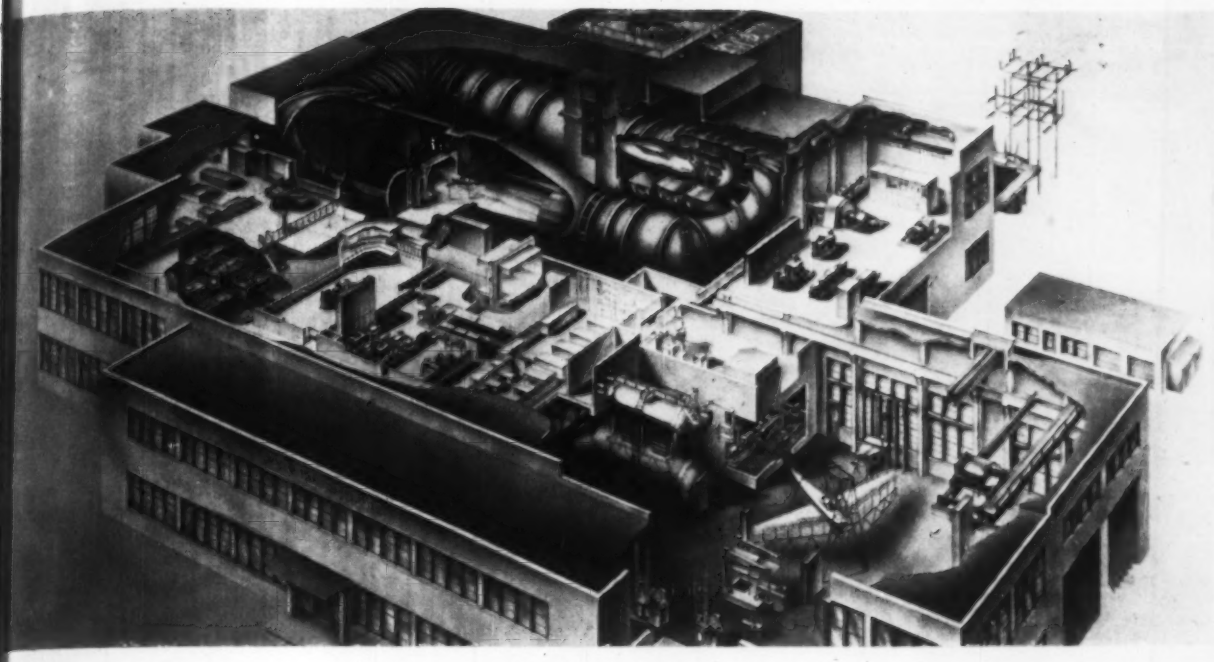

Fig. 1. Plan View of Main Building.

Instrumentation for Aeronautical Research*

By EDWARD C. BLOM, Cornell Research Foundation, Inc., Buffalo, N. Y.

AVIATION has made great strides forward within the past few years. Non-stop flights of five thousand miles and more are becoming quite common. Perhaps in the next few years we may see rockets and atomic energy carry us around the world. There are some who assert that the day of Buck Rogers and Flash Gordon is almost upon us. Yet it was only 44 years ago that the Wright brothers made their first successful flight at Kitty Hawk, North Carolina; the distance covered, 120 feet, less than the wing spread of some of our airplanes today. Neither the Wright brothers, nor we, nor the "astronauts" of the future will advance the science of flight without adequate laboratory facilities and instrumentation especially built for that purpose.

With the outbreak of the war, it became evident to the government and to industry that the United States lagged behind such countries as Germany and England in some fields of applied research. As the war advanced, the need for aircraft research laboratories became more important. The Cornell Aeronautical Laboratory (then known as the Curtiss-Wright Airplane Division Research Laboratory) was built to fill this need. At the close of the war, the Curtiss-Wright Corporation terminated its operations at Buffalo and donated its Airplane Division Research Laboratory to the Cornell Research Foundation in December, 1945. As a non-profit organization devoted to aviation research and development, the Cornell Aeronautical Laboratory fills two needs. It provides research facilities in the field of aviation for private industry and for the government, and it will provide a productive laboratory where graduate students in the field of aviation may acquire experience and work toward advanced college degrees.

The Author

Edward C. Blom graduated with a BS in Electrical Engineering from the University of Michigan in 1944. During 1943-44, he was also engaged in design and maintenance of electromedical apparatus for the University of Michigan, Department of Physiology. Since then he has worked in the Linde Air Products Company research laboratory in Buffalo; with Buffalo Radio Institute and YMCA Vocational Night School; the Physics Department, Cornell Aeronautical Laboratory; and is now Electrical Engineer with The Hays Corporation, Michigan City, Indiana.

E. C. Blom

At present, the laboratory employs a staff of approximately six hundred. There are experts in almost every field of scientific endeavor. With this staff, a project may be carried from the idea stage through the pilot model status to a product that is skillfully engineered and ready for production. However, the Cornell Aeronautical Laboratory does not produce devices for quantity sale. The University and its Research Foundation do not compete in the field of production. The laboratory occupies two buildings—the main building near the Buffalo Airport, and a larger hangar located directly on the airport grounds.

The largest and most complex instrument in the laboratory is the wind tunnel with its control and measuring equipment. With this instrument conditions of actual flight can be simulated while the aircraft is under close observation of its designer. Complicated conditions of pitch, yaw, and roll in the aircraft under test previously detected only by tedious mathematics or by actual flight may now be determined at a considerable saving of time and money. By means of elaborate fans and pumps, air speeds varying from 50 to 700 miles per hour may be attained with air pressures ranging from ¼ atmosphere to 4 atmospheres. In order that

*Presented at the Second Annual Conference of The Instrument Society of America, Stevens Hotel, Chicago, Ill., Sept. 8-12, 1947.

Note: Statements and opinions advanced in papers are understood to be individual expressions of the author and not those of the Society.

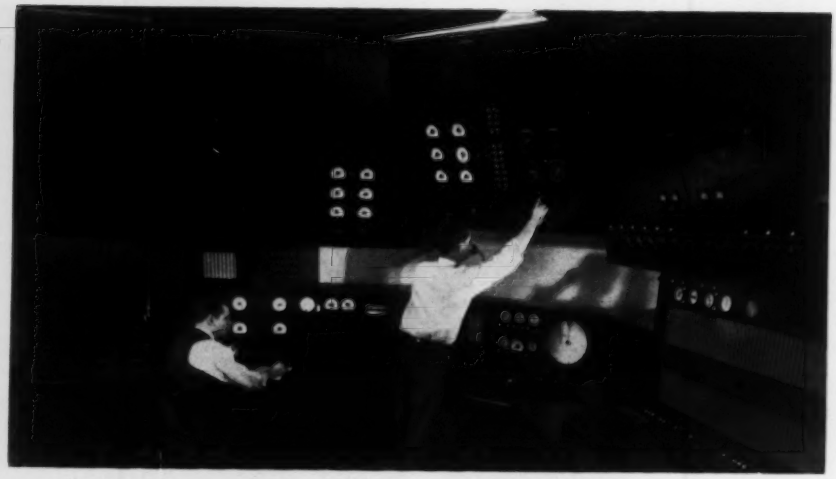

Fig. 2. Wind Tunnel Control Room.

Fig. 3. Data Interpreting Equipment.

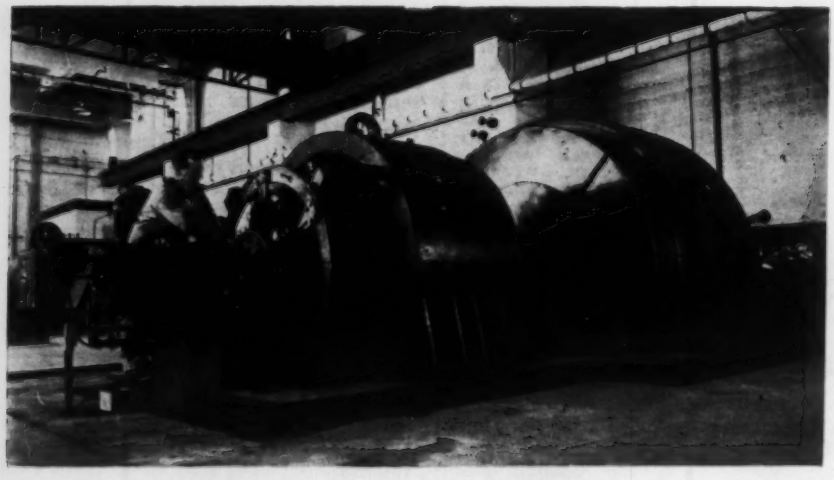

Fig. 4. Wind Tunnel Fan Motor.

the 31 ½ foot diameter tunnel may w
stand the tremendous forc exer
upon its sides when operati at ot
than atmospheric pressure, it was n
essary to construct the walls of ¾ in
steel plate.

The reason for decreasing the pr
sure within the tunnel is quite obvi
but why should it be necessary to ra
the pressure? Certainly there is no ne
to simulate the flight of a plane bel
sea-level. When wind tunnel tests a
made, it is usually necessary to use
duced scale models if the plane is to
within the tunnel test section. Howeve
it is not enough simply to reduce t
scale of the model. Correct test resu
are obtained only when the proper Re
nold's number, characterizing the a
flow, is maintained. This alteration m
best be accomplished by varying t
density of the air within the tunn
and this is why it is sometimes nece
sary to raise the pressure within th
tunnel to as much as 4 atmospheres.

The model transmits its forces throu
three supporting members to hydrau
capsules located in the base frame a
sembly. The forces are then relayed
electrical and hydraulic means to th
wind tunnel control room where the
are registered on large dial indicator
When the operator wishes to record th
readings shown, he operates a switc
which automatically prints and punch
the gauge readings on IBM machi
cards. Later the cards are fed throu
other IBM machines which asso
record, and calculate the data, there
obtaining results for reporting. The i
formation as reported must then be i
terpreted and the results utilized in t
design of future aircraft.

Actually the laboratory has fo
wind tunnels of which the one just d
scribed is the largest. The remaini
three are quite small and are design
to cover the ranges of subsonic, tra
sonic, and supersonic speeds up to
times the speed of sound.

Fig. 5 shows a Schlieren photogra
taken through the window of one of t
small wind tunnels. The dark shape
the center is a cross section of an a
foil or wing under test. The dark lin
issuing from the front and rear edg
of the air foil are caused by sho
waves generated when the rapidly mo
ing air streams pass over the air fo
The configuration is similar to that
the surface waves generated when
boat passes through the water.

The next major piece of laborato
equipment is the altitude chamber. Th
instrument has done much to conser
the engineer's time and men's liv
when new pieces of equipment are b
ing designed. With it, unforeseen pro
lems caused by low temperature and lo
pressure encountered at high altitud
may be detected and solved. It is fa
better to discover these troubles on th
ground where they can be corrected im
mediately, than to have the difficulti
appear when the plane is several mil
up. Too, the chamber is very helpful
introducing the new pilot to the pecul
arities of the high altitudes. Some o
the dangers to the pilot are burstin
of the ear drums, bloating, oxyge
starvation, and the "bends" (a difficult
well known to deep-sea divers). How
ever, things other than personnel a

o affected by low pressures. Electri- equipment is especially vulnerable ause of corona discharge and arc- r in the high voltage circuits. Low peratures cause embrittlement of ber seals and insulation, unequal traction of metal (resulting in seiz- of moving parts), and gumming of ricants.

f all of these troubles present them- ves, why bother with high altitude? y not fly at the low levels where se troubles are not present? There four very important reasons. First, lower altitudes the air affords great- resistance to flight while the higher itude permits much less drag. For mple, a plane than can fly at 200 les per hour at sea level can fly at 0 miles per hour at 50,000 feet for same propeller horsepower output. second advantage is the absence of isture or clouds. This permits seeing eat distances, and also eliminates ngerous icing of the wings. Third, mospheric disturbances at high alti- les are much less violent and are re predictable. Fourth, from a mili- y point of view, planes flying at her altitudes are less vulnerable to ti-aircraft fire from the ground.

If air traffic becomes more dense in future, as it surely will, we may lcome the higher altitudes for extra es of travel.

The altitude chamber can simulate atmospheric effect on a plane climb- at the rate of 3800 vertical feet per nute up to heights as great as 70,000 et and to temperatures as low as 85°F. The chamber is large enough to comodate the entire fuselage of a hter plane if necessary.

Many preliminary investigation flight ulation methods may be used effec- ely but sooner or later it is necessary "go upstairs" and test the plane un- actual conditions. It is a phenome- n familiar to most engineers that a ce of equipment will perform well in laboratory or the repair shop only fail when it is operated in the field. a tool in field testing of airborne paratus, the laboratory has developed used efficient radio telemetering uipment. It would be very difficult to nd several men along during a test to serve and record all of the important t data and to keep the pilot informed any dangers that might develop. This uld add extra weight and would be wise from a safety standpoint. To ercome the difficulty, information is thered from the various pick-up de- ces such as yaw meters, roll detectors, essure and strain indicators, located roughout the test ship. These data y be recorded automatically in the ane or they may be sent by radio to ground. In the instrument developed this laboratory the data are made to pear in the form of fourteen different dio frequency tones, each of whose plitudes is proportional to one of the urteen data being measured. These nes are then mixed to form a complex ne which in turn modulates a fre- ency-modulated radio transmitter. On ground, the mobile receiving station cks up the signal, converts it back to an audio tone, analyzes it into its urteen original tones by means of urteen heterodyne analyzers, and sses it on to recording galvanometers where the wave is recorded on a photographic tape as a faithful representation of the variable being measured on the test plane. At a later time the oscillograph paper will be processed to form a permanent record of the flight. In this way, many of the hours and dollars wasted in repeat flights are saved. Then, too, small troubles, too insignificant to be observed by the busy pilot yet important enough to cause serious trouble, can be detected before it is too late.

Telemetering is by no means limited to airplanes, but the work of the laboratory with airborne objects other than conventional airplanes cannot be discussed here. Maybe someday telemetering will accompany a rocket to the moon.

In closing let me say again that research is essential to advancement in any field of science. If the government and private industry will continue research as an active part of their operations, we will continue to see remarkable advances in all fields of endeavor. The field of aeronautical development is becoming more and more complex as time goes by, and we, as instrument men, will be called upon to develop even more complex instrumentation to meet and meter these advances. The toughest problems are yet to come, and laboratories like the one just described must be there to solve them.

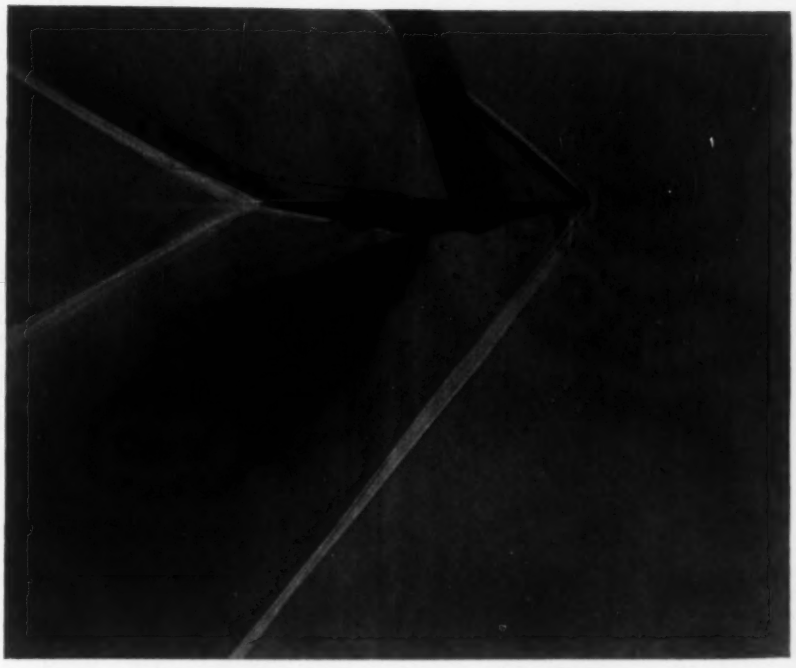

Fig. 5. A Schlieren Photograph.

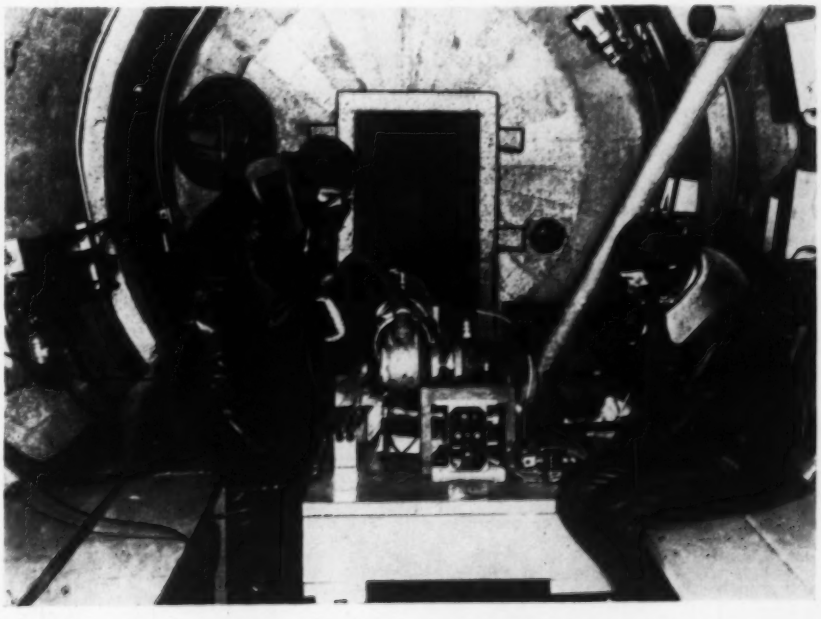

Fig. 6. Inside the Altitude Chamber.

Section News

(Continued from Page 560)

Executive Committee . . . *Harold Fox*—Koppers Co.; *M. M. Fromm*—Westinghouse Electric Corp.

Dick Rimbach then gave a brief report on the Philadelphia meeting, and the chairman then introduced the speaker, Mr. Al Sperry, of Panellitt, Inc., and past President of ISA, whose topic was "Automatic Controllers and Servomechanisms".

The speaker presented a system of classifying devices for automatic control or regulation, in a way that differentiated between automatic controllers (chemical process applications) and servomechanisms (gun fire control, etc.). The difference between them is that while the controller has a constant input or desired value, and is allowed from 10 seconds to 5 or more minutes to return to it after an upset, the servo has a variable input and must follow input changes in one second or less.

An interesting graphical explanation was given of the differences between floating proportional, and derivative controllers. A hot discussion followed the speaker's presentation. It was pointed out that the classification did not admit such variable input devices as automatic volume controllers. Another point was that all the mechanisms discussed obeyed the same mathematical laws, with different values of constants. A very interesting point was made that the valve positioner fitted the servo definition presented.

—M. M. Fromm, *Corr.*

RICHLAND

At the interim meeting March 31, Mr. L. W. Williams, Portland, Oregon representative of the Brown Instrument Co., discussed the Brown Electronik recording potentiometer. As an introduction Mr. Williams gave a short story of the Brown Company. It was started in 1885, now has 13,000 employees in 9 plants and is sold on the use of electronics in recording potentiometers. A recent innovation in the Brown Electronik is the synchro-balance circuit on the multi-point recorders which permits printing to occur as soon as balancy is attained. Special applications and possibilities of the Electronik developed into an interesting discussion.

The concensus of opinion is that the first quarterly dinner meeting held by the Richland Section was a huge success. Our thanks to C. C. Bodmer and G. G. Matthews, program committee members, who arranged for a most excellent steak dinner. The meeting was held April 14 in the American Legion Banquet Hall with 83 members and 4 guests present.

The speaker for the evening was Mr. J. W. Peckham, West Coast representative of the Bristol Meter Co., who spoke on the topic "Pressure Elements". He presented an orderly outline of the basic means of pressure measurement, factors affecting performance and basis for selection of pressure elements. Mr. Peckham then displayed some of Bristol Company's recent productions and gave us some insight into the problems faced by a manufacturer of pressure elements.

Two General Electric 16mm. sound movies were then shown under the title of "Excursions in Science". President E. S. Day announced an interim meeting on "Gas Analysis" and the possibility of another Instrument Department dance in the near future.

—John Flickinger, *Corr.*

ROCHESTER

The fourth meeting of the Rochester Section of the Instrument Society of America was held Tuesday, April 27, at 8:30 P.M. in the Physics Building on River Campus of the University of Rochester, Rochester, New York.

The speaker of the evening was Dr. Angus Cameron of Distillation Products, Inc. of Rochester. Dr. Cameron was employed at Kodak Research Laboratory prior to 1943 when he joined the Staff of Tennessee Eastman at Oak Ridge, Tennessee, working on high vacuum problems at electromagnetic process plant. During the last six years the speaker has been engaged in research and development work related to high vacuum.

Dr. Cameron first defined the various ranges of vacuum 10mm. of Hg. down to 10^{-8} mm. of Hg. The mean free path of nitrogen gas was given for each range to illustrate the scarcity of molecules in vacuum. The industrial process or techniques employing the various stages of vacuum were discussed, beginning with dehydration of food down to 10 mm. of Hg. and continuing on to the mass spectrometer which operates from 10^{-6} mm. of Hg. and lower.

The speaker pointed out several new industrial processes now in wide use which employ high vacuum. The talk was continued with a summary of various pumps, ejectors and equipment used to produce high vacuum. It was pointed out that vacuum is an expensive condition to create. The higher the vacuum, the greater proportional cost; larger volumes being especially costly. In concluding, the speaker described the operation and characteristics of instruments used to measure and indicate vacuum. Manometer, McLeod gages, Pirani gages, thermocouple gages, Knudson gage, the alphatron and the Phillips ion gage were discussed. Following the talk, a thoroughly interesting question and answer period took place. A short business session concluded the meeting.

—Charles W. Covey, *Corr.*

ST. LOUIS

The May 5th meeting featured a talk by Dr. F. W. Bubb, Washington University, on "Automatic Computer Controls". He gave a review of certain developments made during the war on automatic computers, automatic controls, and combinations of both. Some of these devices were the Norden Bomb Sight, B-29 Parallax Computer, K-4 Automatic Gun-Fire Computer-Control, and Control for Composition of Liquid and Gaseous Mixtures. Applications of these principles to industrial processes were illustrated with lantern slides. Pictures were shown of the Phillips Petroleum Company's production network, and of other computers for the petroleum industry.

—H. E. Zeffren, *Corr.*

ment used for light measuremer[illegible] strument of particular use to pi[illegible] was a Ratio Meter which is us[illegible] the ratio of Red to Blue light [illegible] this figure the correct filter can [illegible] to compensate for different film [illegible]

Another instrument which drew much [illegible] tention was a variable transf[illegible] light source coupled so as to ma[illegible] stant watts output, variation of [illegible] explained showing how it could [illegible] maintain either constant curren[illegible] stant voltage output. The speaker presente[illegible] some very excellent color slides [illegible] which showed how it was possible by use [illegible] the Ratio Meter to control the final produc[illegible]

Twenty-three members and guests we[illegible] present for the meeting, at the close [illegible] which a picture of the group was taken b[illegible] Mr. Harold Johnson.

—Marius Wolff, Co[illegible]

SOUTHERN MICHIGAN

In the absence of President Oliver Wood[illegible] the National Delegate, Ken Mead, presid[illegible] at the April Meeting. A nominating com[illegible] mittee was chosen consisting of Mr. W. G[illegible] Marburger, Mr. Wade Allen, and Mr. He[illegible] mer Kuiper. The list of nominees will b[illegible] posted in the June issue of "Instrumenta[illegible] tion News." Wade Allen, the program chair[illegible] man, introduced Mr. Lyle Eige of the Fish[illegible] er Governor Company, Marshalltown, Iowa[illegible] who spoke on "Fundamental Principles o[illegible] Self-Operating Controllers".

A group of members of the South Bend Section of I.S.A. at their April 8 meeting.

SARNIA

The April meeting of the Sarnia Section was held in the Polymer Cafeteria, Friday, April 16, at 8:00 P. M. This meeting turned out to be one of the best meetings held so far by this Section with a gathering of 275 members and guests.

The speaker of the evening was Mr. Richard Pond of the Taylor Instrument Companies of Rochester, New York. Mr. Pond's subject was "Demonstration of Automatic Control Principles" and the large turnout was treated to a very interesting evening. His presentation was divided into two sections: the first part pertaining to the story of a Chemical Manufacturer and his problem of obtaining an Automatic Control for controlling a drying process; the second part of the talk consisted of a demonstration utilizing a liquid level control process with each type of control being described and demonstrated.

We were very pleased to have some of the new members of the Detroit Section attend this meeting. At the close of the meeting our President, Jerry Elder announced the newly elected officers for 1948-49.

President . . . *Mr. J. W. Graeb*, Imperial Oil Limited.
Vice-President . . . *Mr. K. Goldring*, Polymer Corporation Ltd.
Secretary . . . *Mr. J. Elder*, Imperial Oil Limited.
Treasurer . . . *Mr. J. Almey*, Dow Chemical of Canada.

These officers will be installed at the next meeting.

—L. Gilbert, *Corr.*

SOUTH BEND

The South Bend Section met in room No. 5, Engineering Building, University of Notre Dame, April 8. The speaker of the evening was Mr. Harvey P. Rockwell, Jr.

Mr. Rockwell in his presentation of the lecture, "Instrumentation Used in Light Measurement", showed both slides and demonstration models different types of equip-

Mr. Eige covered his subject well, usi[illegible] interesting analogies to illustrate vario[illegible] points in the talk.

—R. J. Schofield, Se[illegible]

TENNESSEE

The Tennessee Section held its annu[illegible] business meeting on May 13 at the Frank[illegible] lin Club, Elizabethton, Tennessee. A dinne[illegible] at 7:00 P.M. was attended by a majorit[illegible] of members with the business meeting fo[illegible] lowing.

Retiring President, Frank Theile calle[illegible] the meeting to order and reports and dis[illegible] cussion on the annual June outing we[illegible] covered. The activities of the past yea[illegible] were covered in a report by the Secretary[illegible] Mr. A. W. Bright gave the treasurer's re[illegible] port.

The following officers were elected for th[illegible] coming year:

President . . . *Robert Parris*, Americ[illegible] Bemberg Corp.
First Vice-President . . . *J. H. Rion*, Ten[illegible] nessee Eastman Corp.
Second Vice-President . . . *J. W. Selb[illegible]* Tennessee Eastman Corp.
Treasurer . . . *J. D. Hattaway*, Tennesse[illegible] Eastman Corp.
Secretary . . . *L. W. Thayer* was elected last year for a term of two years.
National Delegate . . . *J. T. Elder* was elected last year for a term of two years.

—L. W. Thayer, Sec'y

TULSA

The Tulsa Section conducted an electio[illegible] at its May 3rd meeting. The following wer[illegible] elected to take over before resumption o[illegible] meetings in September:

President . . . *R. G. Huggins*, Mid-Continent Petroleum Co., 1319 W. 23rd Place Tulsa 7.
Executive Vice-Pres. . . . *J. M. Ribble*, Phillips Petroleum Co., 2009 Johnston Bartlesville.

Vice-Pres. (Membership) . . . *F. N. Davis*, Daniel Orifice Fitting, Thompson Building, Tulsa.
Vice-Pres. (Programs) . . . *J. L. Cottrel*, Pittsburgh Equitable Meter Co., 3130 Sand Springs Rd., Tulsa.
Secretary . . . *C. R. Horton*, Macnick Division, 510 South Lansing, Tulsa.
Treasurer . . . *L. O. Barnett*, Vinson Supply Co., 220 N. Boston, Tulsa.
Executive Director . . . *J. E. White, Jr.*, Stanolind Pipe Line Co., Capital Oil Bldg., Tulsa.
Executive Committee (one year) *Paul G. Exline*, Exline Engineering Co., 716 S. Troost, Tulsa.
Executive Committee (two years) *E. J. Armstead*, Stanolind Pipe Line Co., Stanolind Bldg., Tulsa.
The June meeting will be a social affair with a dinner.

—C. R. HORTON, *Sec'y.*

WASHINGTON

Effective January 1, 1948, the units used throughout the world for the measurement of electrical quantities were changed abruptly by international agreement. The new values were chosen to give the best possible approximation to the theoretical values consistent with the mechanical units of length, mass and time. In the April meeting, Dr. F. B. Silsbee, Chief of the Division of Electricity and Optics, National Bureau of Standards, discussed "The New Electrical Standards," the reasons for this change, and the methods by which the values of the basic electrical units are established and maintained.

A report on the "Conference on Electron Tubes for Instrumentation and Industrial Uses" was presented as the second talk of the evening by J. Gilman Reid, Jr. of the Electronic Instrumentation Division, National Bureau of Standards. The conference was held under AIEE sponsorship in Philadelphia, on March 29, and 30, 1948. Its purpose was to bring together instrument designers and vacuum tube manufacturers for discussing the special requirements of the instrument industry with regard to electron tubes. The conference was reported in summary by Mr. Reid, who served as chairman of the conference program committee.

The subject of adjourning for the summer months was brought up in the Executive Council Meeting and it was decided that no regular meetings would be scheduled for the months of June, July, August, and September. A possible inspection tour or similar special meeting was approved however, and in the event of such a meeting, a special notice to all members would serve as notification.

—R. E. HADADY, *Corr.*

WAYNE COUNTY

At our April 19th meeting we had visitors from Battle Creek, Cleveland, Toledo and Detroit. There were about 45 present. The door prize, a Weston Thermometer, was won by Mr. Munchausen of the Detroit Edison Company.

Election results were as follows:

President .....*Russell Cushing*
First Vice-President.....*Bob Wright*
Second Vice-President....*To be filled later*
Secretary .....*Ross Swenson*
Treasurer .....*Robert Carr*
ISA Representative .....*George Huff*

We enjoyed and appreciated the talk and accompanying slides by Mr. M. H. Ingsley, Vice-President of the Hays Corporation. Various applications of electronic instruments in measuring process variables were shown and described. We were especially interested in a new oxygen recorder.

—JOHN MACPHERSON, *Corr.*

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• • •

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• • •

INSTRUMENT MECHANIC (2) experienced in servicing process instruments, capable of installing, calibrating and maintaining all types of mechanical, electrical and pneumatic instruments. Starting rate $1.89 per hour. Location New Jersey. Box 143.

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